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William Chadwick

Wm. King

THE AMERICAN

ARTIST'S MANUAL,

OR

DICTIONARY OF PRACTICAL KNOWLEDGE

IN THE

APPLICATION OF PHILOSOPHY

TO

THE ARTS AND MANUFACTURES.

Selected from the most complete European Systems,

WITH

ORIGINAL IMPROVEMENTS

AND

APPROPRIATE ENGRAVINGS

ADAPTED TO

THE USE OF THE MANUFACTURERS OF THE UNITED STATES.

BY JAMES CUTBUSH.

IN TWO VOLUMES—VOL. I.

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TO

BENJAMIN SMITH BARTON, M. D.

PROFESSOR OF THE THEORY AND PRACTICE OF MEDICINE, AND OF NATURAL HISTORY AND BOTANY, IN THE UNIVERSITY OF PENNSYLVANIA,

THIS WORK IS DEDICATED

BY THE EDITOR,

AS A TESTIMONY OF ESTEEM

FOR HIS PRIVATE, AND RESPECT FOR HIS PUBLIC,

CHARACTER.

PREFACE.

THE Editor of the Artist's Manual having completed the task he had undertaken, now offers it to the public.

It will occur to the mind of the candid and enlightened reader, that a work professedly treating of most, if not all the useful Arts and Manufactures, cannot be the production of an individual; neither can a proper selection from the best publications, be made without assistance.

To this assistance the Editor has frequently had recourse; and while he hopes the work may give general satisfaction, he feels a confidence that no expense has been spared by the publishers or himself, completely to fulfil the proposals of the prospectus.

It was not to be expected that the United States, possessing such an extensive territory, and with a population so small compared with the older countries of Europe, where the number of inhabitants insures manual labour at a moderate price, could have, hitherto, made equal advances in the arts and manufactures. Recent experience has however shewn us what the united efforts of industry and enterprize, conducted by the inventive talents of our countrymen, are capable of effecting. The time has already arrived, when a general diffusion of the knowledge of Europe on these subjects, cannot fail of being highly interesting and beneficial amongst us. And as we are indebted to foreign publications, for some of the best

treatises made use of, this necessarily makes the present more a work of selection than of original matter. At the same time it may be observed, that every opportunity to avail himself of the experience of his countrymen, has been sought for by the editor, and much important information, has been thus cheerfully afforded him. To those from whom he has borrowed, both in Europe and America, it has been uniformly his wish to do justice, by giving the name of the author, with the quotation.

Of such original essays as the editor has furnished, they are the result of much study and practice, having devoted the greater part of his life, to chemical pursuits. He therefore feels a confidence that they will not be found uninteresting to such as are engaged in those arts, which are purely chemical, or are largely connected with that science.

With these general observations the work is submitted to a candid public, with a hope that it may be found deserving of approbation and encouragement.

THE

ARTIST'S MANUAL;

OR,

DICTIONARY OF PRACTICAL KNOWLEDGE.

ACETOUS ACID. As this important acid is, for the most part, though not always, the product of a fermentation consequent to the vinous, and formed of the same general materials, we have referred to the articles *Fermentation* and *Vinegar* the description of the process of vinegar-making, the *rationale* of this operation, and the domestic uses of this acid; we shall therefore in this place only describe some of the properties of the pure acetous acid.

The sources whence this acid may be procured are very numerous, more so than has commonly been supposed. It is found native in several vegetable juices, particularly in the SAP of various trees. It is procured not only from vinous fermented liquors, but from most mucilaginous, insipid, extractive animal or vegetable matters, when they turn sour by spontaneous change. Thus the moulding of starch, of moistened flour of any kind, of animal jelly, and even of urine, and the souring of milk, is in some degree a process of acetification.

Pure acetous acid is usually procured from common vinegar, the distillation of which is carried on in the large way by the druggists, for general purposes, and for the preparation of sugar of lead; in some parts of the south of France for the preparation of verdigris; with these it is distilled in a tinned copper vessel, as the action of vinegar upon tin is but slight. A watery and slightly acid vapour first condenses, which is a very weak acetous acid, and may be set aside. Then the distilled liquor still continuing equally clear and colourless, but a little empyreumatic in smell and taste, becomes more strongly acid, and continues so to the last. This is the common acetous acid or distilled vinegar. Towards the end of the process, the residue is very apt to acquire and communicate a burnt smell and taste: this is prevented by carefully regulating the fire, and, if it be worth while, by adding to the liquor a little warm water; but when about five-sixths of it is distilled, the process should be discontinued, as the residue is of little or no value.

The truly acid part of the purified acid is still mixed with a large portion of water. Means have been devised for condensing or concentrating the acid in a smaller bulk. Distillation alone, is not competent to this purpose; for, though some of the water rises nearly pure at first, yet it soon becomes very sour, as the acid is almost equally volatilized by heat, and by water.

The effect of frost in concentrating vinegar is very striking. If a quantity of this acid, distilled or not, be set out in the air in winter, when the cold is below 26° a tender flaky ice forms in the liquor,

and renders a large portion of it solid; on breaking it, a portion, still fluid, is found beneath, which is to be carefully drained off from the ice. This fluid is the acetous acid, concentrated by the loss of all the frozen part, which last is tasteless or very nearly so, and is little else than pure water. A further exposure of the strong acid to a sharper cold, will produce a similar and increased condensation, till at last the process must be stopped, either on account of the cold not being now sufficient to separate the water from the constantly strengthening acid, or from the ice itself becoming acid.

A more effectual mode of concentrating this acid is by previous union with an alkali, an earth, or a metallic oxyd, and bringing it, by evaporation, to a solid consistence. In doing so, all the superfluous water of the acid is separated, and if the acid be afterwards expelled from the salt by means of a stronger affinity, it appears in the most concentrated form of which it is capable.

The first process is to saturate pure distilled vinegar with mild soda, filter the solution, evaporate to a sirupy consistence, and suffer the acetited soda to crystallize. Dry the salt thus obtained, powder it, put it into a tubulated retort luted to a large receiver, add half its weight of strong and quite colourless sulphuric acid, and distil on a sand bath with a gentle heat, nearly to dryness. If it rises mixed with sulphuric or sulphureous acid, redistil it off a little clean clay.

This acid is excessively volatile and pungent, and also inflammable. However, it always contains sulphuric and sulphureous acid, from which it may be separated with great ease, by adding acetited barytes, as long as any white precipitate falls down.

The acid thus highly concentrated is crystallizable by cold; but another method which answers as well, is to mix and put into a retort two parts of dry acetited soda, with eight parts of dry crystallized *acidulous* sulphat of potash, and distil with a gentle heat. The process goes on speedily even in a weak fire, and two parts of a very strong acetous acid are obtained. By this method no contamination with sulphuric acid is to be feared. This acetous acid, in a temperature of about 38°, or a little higher than freezing water, shoots into either fine arborescent feathery crystals, or else into a confused striated mass. It remains unthawed till about 59°.

We proceed to mention that variety of acetous acid, formerly known under the name of *radical vinegar*. It is procured by distillation of the metallic acetous salts, more especially the acetite of copper, or *distilled verdigris*.

This may be procured in various methods: but the following is the most œconomical process: mix equal parts of sulphat of copper and acetited lead, distil with a gentle fire. A very pleasant and extremely pungent radical vinegar comes over, about a third of the weight of the ingredients used. The acetic acid, procured from the salts of copper, is distinguished by a light greenish colour and a coppery smell, which makes an unpleasant addition to the agreeable pungency of the acid. An acid, similar at least in most sensible properties, may be obtained from the acetite of lead, not by distillation, but by the addition of sulphuric acid, for none of the metallic, or alkaline, or earthy acetites, that have been subjected to experiment, will yield their acid, undecomposed by simple distillation, except the acetite of copper. Six ounces of sulphuric acid, added to twelve ounces of sugar of lead, and distilled with a gentle heat, will give seven ounces of a very concentrated caustic vinegar. In this, however, as in most of those processes where the naked sulphuric acid is added, the product is contaminated towards the end of the distillation.

The uses to which the acetous acid in its purified state is applied, are not very numerous. The most important is in the manufacture of sugar of lead and verdigris. It is used largely in medicine. None of the acetites, besides those of copper and lead, are employed to any extent, except in pharmacy and in the laboratory.

The tests to discover the presence of acetous acid in any mixture, are not very obvious or direct. If the substance to be examined contains the acid in an uncombined state, it should first be saturated with an alkali, and evaporated very gently to dryness. Then the affusion of a few drops of sulphuric acid on a small portion of the residue, assisted by a gentle heat, will displace the acetous, and give the agreeable pungent acid vapour, by which this latter is characterized.

For the chemical properties of acetous acid, see the different treatises on chemistry. Also see *Vinegar*.

ACETOUS ACID. *Empyreumatic*.

A great number of vegetable substances when strongly heated in close vessels, so as to destroy their organization and texture, yield, among other products, a considerable quantity of a bitterish, pungent, sour liquor, which is always more or less turbid and dark coloured; is incapable of crystallization, unites with alkalies, earths, and some metallic oxyds, forming,

for the most part, brown and foul-looking compounds, generally deliquescent.

On account of some little variety when procured from different substances, they have been distinguished from each other, and till of late, were considered as separate species.

They are the following:

1. *Empyreumatic Acid of Sugar, Syrupous Acid*, or *Pyromucous Acid.*

2. *Empyreumatic Acid of Tartar*, or *Pyrotartareous Acid*, also to be carefully distinguished from an acid of similar name, but totally different nature, *Tartareous Acid.*

As the foregoing varieties are seldom applied to the arts, on account of their expense, we have thought any account of their preparation unnecessary.

3. *Empyreumatic Acid of Wood, Ligneous Acid*, or *Pyroligneous Acid.*

To procure it, distil any quantity of shavings of any kind of wood, such as box, guiacum wood, or beech, and an extremely strong-smelling, dark-coloured empyreumatic acid liquor is obtained, nearly one-third of the weight of the wood. This acid is sourer, and also much blacker and more empyreumatic than the two former, probably as requiring a stronger heat for its production. The acid of wood is obtained in a large quantity near London, from the preparation of charcoal for Gunpowder, by distilling wood in cast-iron cylinders. It stains the hands deeply, and wood indelibly.

The three varieties of empyreumatic acid above mentioned, are all capable of very considerable purification by easy methods, and in proportion as they become purer, they lose their empyreuma, their peculiar taste and smell, and consequently their characteristic differences, till at last, when brought into the most concentrated state by some of the methods in which vinegar is dephlegmated, they all exhibit the characters of acetous acid in so unequivocal a manner, that no doubt can now be entertained of their identity.

Charcoal, newly burnt and powdered, has a great effect in purifying all these acids: they may be either gently distilled off it, or even merely filtered through a stratum of it. But the most effectual method of purification, is by uniting these acids with lime, or a fixed alkali, evaporating to dryness, and then expelling the acid by means of the sulphuric, in the same manner as the concentrated vinegar is prepared.

The pyroligneous acid alone is procured in such a quantity as to be an object for manufacture. At the best it is only an inferior acetous acid, and the difficulty of purifying it will forbid its profitable use in many of the arts to which vinegar is applied. However, as the process for procuring radical vinegar at the same time purifies this empyreumatic acid, it may probably be used for this purpose.

We may add, that much of the acid from the distilled charcoal for gunpowder, near London, is employed by calico-printers in forming the acetited iron, used as a mordant, as here the colour and smell of the acid are in no way detrimental.

ACIDS.—We shall only treat of such acids as are of importance in the arts; such as sulphuric acid, or oil of vitriol, muriatic acid, or spirit of salt, &c. Acids are a peculiar class of bodies which are possessed of certain general properties, as follow.

1. Their taste is sour, and, unless diluted with water, corrosive 2. They change blue vegetable colours to red. 3. Most of them unite with water in all proportions; and many have so strong an attraction to that fluid, as not to be exhibited in the solid state. At a moderate temperature, or in the humid way, they combine with alkalis so strongly, as to take them from all other substances. 5. They combine with most bodies, and form combinations attended with many interesting phænomena; upon the due explanation of which great part of the science of chemistry depends.

ACID, Acetous. See *Acetous Acid.*

ACID, Arsenic. See *Arsenic Acid.*

ACID, Citric. See *Citric Acid.*

ACID, Gallic. See *Gallic Acid.*

ACID, Muriatic. See *Muriatic Acid.*

ACID, Muriatic Oxygenized. See *Oxygenized Muriatic Acid.*

ACID, Nitric. See *Nitric Acid.*

ACID, Prussic. See *Prussic Acid.*

ACID, Sulphuric. See *Sulphuric Acid.*

ADULTERATION, is the corrupting of any substance, by mixing with it something of less value. Wines are sometimes adulterated with lead and copper, to improve their taste; but, as these metals are of a very poisonous quality, the following valuable test is given to detect their presence.

Equal parts of oyster shells and crude sulphur, are to be kept in a white heat for a quarter of an hour; and, when cold, this is to be mixed with an equal quantity of acidulous tartrite of potash, or cream of tartar, and put into a strong bottle with common water for an hour, and then decanted into bottles holding an ounce, with twenty drops of muriatic acid each.

This liquor precipitates the least quantity of lead, copper, &c. from wines, in a

very sensible black or dark brown precipitate. See TESTS.

AFFINITY, or *Attraction.* Almost all the phænomena of nature may be ultimately referred to two kinds of motion, attraction and repulsion. Attraction may again be subdivided into that which takes place between bodies at sensible distances, including gravitation, magnetism, and electricity; and that which acts only at insensible distances, such as cohesion and chemical affinity.

Cohesion, or homogeneous affinity, is the attraction between the component particles of homogeneous bodies, as between two globules of quicksilver: when made to touch each other, they run together into one globule, and are mixed in the most intimate manner, without however undergoing any alteration in their chemical or physical properties.

Chemical or heterogeneous affinity can only take place between dissimilar particles; and the change of properties which is the consequence of this combination, cannot, in the present imperfect state of our knowledge, be inferred from those of the elementary particles. As when quicksilver is added to melted sulphur, the result is a compound possessed of neither the colour, the splendor, the inflammability, the volatility, nor specific gravity of either of its constituent parts.

These two affinities are the great agents in all the operations of nature and art, which are referable to the science of Chemistry; not only as instruments of Synthesis, as might be supposed from the primary meaning of the term, but also as the sole means of analysis, there being no way of resolving a chemical compound but by exposing its elements to the action of stronger affinities than those which retain them in union. See *Fourcroy's Chemistry.*

AGRICULTURE claims a pre-eminence above manufactures and commerce, from its seniority and superior usefulness, and to use an expression of the celebrated Sully, may be regarded as the breasts from which the state derives its support and nourishment. Manufactures and commerce originally owed their existence to agriculture; and the people employed in carrying them on, must constantly be fed by those who are engaged in the parent art. Agriculture may, therefore, be considered as of the first importance to mankind; because their temporal welfare and prosperity depend upon receiving a regular and sufficient supply of the various articles cultivated by the agriculturist. In an age like the present, when the utility of agriculture is so fully recognised, it is unnecessary to dwell at length upon the advantages which every individual, we may say every nation, must enjoy when that art is sufficiently understood and skilfully practised. Passing by the history and tedious forms of division, subdivision, &c. which are usually practised in treating on this subject, we shall make a few observations on the theory, and then proceed to the practical part of farming.

1st. *On the Theory of Agriculture.*—We consider the numberless hypotheses that have been presented respecting the organization and food of plants, or the principles of vegetation, as quite foreign to a treatise on agriculture. The operative farmer could not thereby be benefitted in the smallest degree, nor would any part of his practice be illustrated or improved; perhaps, on the contrary, he might be led out of the right path into the vortex of delusion, and induced to forsake that system of practice, which is sanctioned by experience; and which ought to be his only guide. We are inclined to believe, that a degree of certainty is already attained, concerning the real and efficient theory, sufficient either to guide or determine the conduct of those engaged in carrying it on.

If the earth is enriched by generous manures, or stimulated by powerful cordials, as circumstances may require; if it is laid dry, or drained of superfluous water; if the soil is sufficiently cultivated, and its aboriginal inhabitants, namely weeds, are removed; and if, in naked and exposed situations, shelter is afforded, by making enclosures, then every thing, that man is capable of doing to forward the productive powers of the earth, is completely executed. In short, the man who is governed by these principles, may be pronounced to possess more knowledge of the art than the most scientific agriculturist. The one acts upon principles which never can fail, and which uniformly lead to the same issue; the other is guided by no certain principle whatever, but led by an *ignus fatuus*, whose delusions may draw him into bogs and quagmires, where he may flounder for a while, and at last be ruined and made miserable, both in fortune and reputation.

The theory of agriculture, which we lay down, is therefore built upon the following fundamental principles; and with one or other of them every part of rural practice is more or less connected:—*First,* That the soil ought to be kept dry; or, in other words, free of all superfluous moisture. *Secondly,* That it ought to be kept clean; or, in other words, free of noxious weeds. *Thirdly,* That it ought to be kept rich; or, in other words, that every particle of manure, which can be

collected, ought to be applied, so that the soil may be kept in a state capable of yielding good crops. Every person, possessed of a sufficient capital stock, may act according to the first and second principles; but it is only where local circumstances are favourable, that the last can be carried completely into effect. No more, however, being required of the farmer, than that he shall make the most of his situation, the principle applies equally to all; and, in like manner is equally correct and beneficial in all situations and circumstances.

In the first place, the utility, nay the necessity, of keeping land dry, and preserving it from being inundated or flooded with water, is so obvious, that few arguments will be required in support of this primary principle. When land is allowed to remain in a state of wetness, which may either be occasioned by spouts, or springs, in the under soil, or by rain-water stagnating on the surface, the earth gets into a sour state, which afterwards is detrimental to the growth of plants; and often, in the first instance, prevents either ploughing or harrowing from being successfully effected. Under such circumstances, the young plants, either of corn or grass, become yellow and sickly, and never assume that vigorous thriving aspect, which they maintain upon fields differently circumstanced. Besides, manure has not the same effect when the earth is drowned, or even injured with wetness, as when it is kept dry and free from superfluous moisture. Under-draining is the only method of correcting the evils arising from spouts, or springs, and digging out the head-land, and *gau-furrows*, the only preventive against surface-water, when heavy falls of rain or snow storms ensue. In fact, without attention to these important operations, arable land can neither be perfectly managed, nor full crops reaped. Perhaps, the goodness or badness of farm-management may be as correctly estimated by the attention shown to drainage, as by any other mark whatever. Where drainage is neglected, a sure proof is furnished, that many other branches of the art are imperfectly executed. Unless this branch of rural œconomy is assiduously attended to, the advantages arising from ploughing and manuring are only partially obtained.

In the second place, the benefit arising from keeping the land clean is sufficiently discernible. Weeds, whether of the annual or perennial sorts, may be regarded as preferable creditors of the soil, who will reap the first advantage of manure, if allowed to remain in possession: their removal therefore forms an important object of the husbandman's attention. It may be stated, that, according to the degree of success that follows the means employed, so will the goodness or badness of the husbandman's crops be regulated. If the strength, or nutritive powers of the soil be exhausted or drawn forth by weeds, or such plants as the soil naturally produces, it is impossible that artificial plants can prosper.

In the third place, the necessity of restoring to the soil, in the shape of manure, the powers drawn from it by artificial crops, is acknowledged by almost every person. Manure, in fact, is the most powerful agent in the hands of the farmer, and the attention bestowed upon collecting, preparing, and applying it, constitutes an important branch of the art, which he practises. Perhaps agriculturists are more behind, in the points connected with this third general principle, than in the others; and here the utility of chemical knowledge may, in some respects, be estimated and recognised.

These three fundamental principles hang or fall together. Without laying land dry, neither the advantages of good ploughing, nor the benefits arising from manure can be fully obtained. When any of the other principles are neglected, similar defects will necessarily ensue. But when they are all acted upon; when the land is kept dry, clean, and in good heart, the husbandman may expect a suitable reward for the trouble and expense bestowed on its cultivation. An agricultural code of this kind is not only a true one, but has the particular merit of being simple and distinct; nay, it has an advantage which few creeds possess; it may be understood by the dullest capacity. Were it carried into execution, were the operations of farmers regulated by its tenets, were their endeavours constantly directed to keep the lands in their possession dry and clean, and as rich as possible, then the country would be progressively improved.

On Soils.—Soil, strictly speaking, is the ground or earth wherein crops of every kind are produced; and we notice it in this way merely to distinguish the surface from the under stratum or subsoil on which the surface is incumbent. The value or worth of that part of the earth, which is the object of cultivation, depends materially upon the nature of the under stratum; because, when the latter is close or extremely retentive of moisture, the expense and hazard of cultivating the surface is considerably increased, whilst the growth of plants cultivated upon it is much abridged and impeded, particularly in adverse seasons.

The nomenclature of agriculturists, with regard to soils, being variable and indistinct, it is a difficult task to describe them, or to mark with any degree of accuracy the shades which distinguish one from another, so nearly are many of them connected. Generally speaking, the component parts of soil, whatever may be the color, are argill, silex or sand, water, and air; for into these original principles may all earths be reduced, however blended with apparently foreign substances. Argill is the soft and unctuous part of clay. The primitive earths, argill and sand, contain each, perhaps in nearly equal degrees, the food of plants; but in their union the purposes of vegetation are most completely answered. The precise quantities of each necessary to make this union perfect, and whether they ought to be equal, it is neither very easy nor very material to ascertain, since that point is best determined in practice, when the soil proves to be neither too stiff or adhesive, from the superabundance of clay, nor of too loose and weak a texture, from an over quantity of sand in its composition. The medium is undoubtedly best; but an excess towards adhesion is obviously most safe. A stiff or strong soil holds the water which falls upon it for a long time, and, being capable of much ploughing, is naturally well qualified for carrying the most valuable arable crops. A light soil, or one of a texture feeble and easily broken, is, on the ordinary, soon exhausted by ploughing, and requires renovation by grass; otherwise it cannot be cultivated to advantage.

Soils may be considered and characterized, as far at least as is necessary for practical purposes, under the distinctions of Clayey, Loamy, Chalky, Sandy, Gravelly, and Peaty or Mossy. Each of these diversities, of course, comprehends several varieties, according to the nature and preponderance of the different sorts of materials of which they are composed.

Loam has generally been considered as an original earth, though we are disposed to view it as an artificial soil, produced by calcareous matters, and animal and vegetable manures. The strongest clay may, in process of time, be converted into a loam, by repeated applications of these substances; and the richness or freeness of that loam will depend entirely upon the quantity of manure with which it has been supplied. Sandy soils may also be converted into light loams, by the application of lime, chalk, marl, and especially clay. Even peat may be converted into a black soft loam, and in various ways rendered fertile and productive. From these circumstances, a degree of confusion prevails respecting the nature and properties of soils, which renders the subject more difficult than at first sight might be expected. Even the admixture of surface and subsoil, by deep ploughing, creates a change of considerable magnitude.

A clay soil, though distinguished by the colour which it bears, namely black, white, yellow, and red, differs from all other soils, being tough, wet, and cold, and consequently requiring a good deal of labour from the husbandman before it can be sufficiently pulverized, or placed in a fit state for bearing artificial crops of corn or grass. Clay land is known by these qualities, or properties. It holds water like a cup, and once wetted does not soon dry. In like manner, when thoroughly dry, it is not soon wetted; if we except the varieties which have a thin surface, and are the worst of all to manage. In a dry summer, clay cracks, and shows a surface full of small chinks, or openings. If ploughed in a wet state, it sticks to the plough like mortar, and in a dry summer the plough turns it up in great clods, scarcely to be broken or separated by the heaviest roller.

Sandy soils next come under consideration. Soils of this description are managed with infinitely less trouble and at an expense greatly inferior to what clays require; but at the same time the crops produced from them are generally of smaller value. There are many varieties of sand, however, as well as of clay; and in some places, the surface is little better than a bare barren sand, wherein artificial plants will not take root, unless a dose of clay or good earth is previously administered. This is not the soil meant by the farmer when he speaks of sands. To speak practically, the soil meant is one where sand is predominant, although there be several other earths in the mixture. From containing a great quantity of sand, these soils are all loose and crumbling, and never get into a clod, even in the driest weather. This is the great article of distinction betwixt sands and sandy loams. A sandy loam, owing to the clay that is in it, does not crumble down, or become loose like a real sand, but retains a degree of adhesion after wetness or drought, notwithstanding the quantity of sand that is mixed with it. Perhaps a true sandy loam, incumbent upon a sound subsoil, is the most valuable of all soils. Upon such, every kind of grain may be raised with advantage, and no soil is better calculated for turnips and grass.

The real sands are not favourable to the growth of wheat, unless when preceded by clover, which binds the surface,

and confers a temporary strength for sustaining that grain.

We have now to speak of gravelly soils. The open porous nature of these soils disposes them to imbibe moisture, and to part with it with great facility; from the latter of which circumstances they are subject to burn, as it is termed, in dry seasons. The main difference between gravel and sand is, that the former is chiefly composed of small soft stones; though, in some instances, the stones are of the silicious or flinty nature, and, in others, of the calcareous and chalky. From these constitutional circumstances arises the propriety of deepening gravelly soils by coats of marl or earth, and of keeping them fresh by frequent returns of grass, and repeated applications of manure. Gravelly soils, from the lightness of their texture, are not expensive or difficult in the means of cultivation. All the necessary business required for gravels may be carried forward with ease and expedition; and such soils are, in general, soon brought into a proper state for the reception of crops.

From what is said respecting gravels, it will appear, that naturally they are barren, unless when mixed with other earths; and that the surface of most of them would exhibit the same appearance as the subsoil, or what is beyond the reach of the plough, were it not changed and meliorated by vegetable matters. The constitutional qualities of gravels also point out the propriety of ploughing them deep, so that the surface soil may be augmented and greater room given to the growth of the plants cultivated on them. A shallow-ploughed gravel can stand no excess of weather, however enriched by manure. It is burnt up by a day or two of drought, and it is almost equally injured by an excessive fall of rain, unless the pan or firm bottom, which such soils easily gain, be frequently broken through by deep ploughing. According to an old adage, the top of clay, and the bottom of gravel, are best; but though we cannot subscribe to the first part of the adage, being satisfied that deep ploughing is highly beneficial, except where the subsoil is of a poisonous nature, we are certain that the latter is well founded, and ought never to be overlooked.

Peat earth, or moss is the next kind of soil which we have to treat of; though we are very uncertain whether, like loam and garden mould, it ought not to be viewed as an artificial soil, made and produced by certain substances deposited on the surface of the earth, and not one originally created, or to be found in the early ages. Satisfactory accounts concerning the formation of moss, the uses to which it may be applied, and the means of removing it, have not yet been discovered.

Soils, therefore, differ considerably from each other, according to the proportions of the different earths, of which they consist. To determine what are the requisites which distinguish or constitute arable or fruitful soils, is of much importance to the farmer. Since vegetable substances evidently imbibe from the earth and surrounding atmosphere, the principle of oils, mucilage, and other peculiar products only found in organized substances; it can hardly be doubted, but that manure, or the remains of decayed substances, render lands fruitful, by supplying these materials ready formed. What remarks we have to offer on the subject of *manure*, will be found under that head. We shall offer the following additional observations, which are drawn, principally, from analytical investigations.

In cases where a barren soil is examined with a view to its improvement, it ought in all cases, if possible, to be compared with an extremely fertile soil in the same neighbourhood, and in a similar situation: the difference given by their analyses would indicate the methods of cultivation, and thus the plan of improvement would be founded upon accurate scientific principles.

If the fertile soil contained a large quantity of sand, in proportion to the barren soil, the process of melioration would depend simply upon a supply of this substance; and the method would be equally simple with regard to soils deficient in clay or calcareous matter.

In the application of clay, sand, loam, marl, or chalk to lands, there are no particular chemical principles to be observed; but when quicklime is used, great care must be taken, that it is not obtained from the magnesian lime-stone; for in this case, it is exceedingly injurious to land. The magnesian limestone may be distinguished from the common limestone by its greater hardness.

When the analytical comparison indicates an excess of vegetable matter, as the cause of sterility, it may be destroyed by much pulverization and exposure to air, by paring and burning, or the agency of lately made quicklime. And the defect of animal and vegetable matter must be supplied by animal or vegetable manure.

The general indications of fertility and barrenness, must necessarily differ in different climates, and under different circumstances. The power of soils to absorb moisture, a principle essential to their pro-

ductiveness, ought to be much greater in warm and dry countries, than in cold and moist ones; and the quantity of fine aluminous earth they contain should be larger. Soils likewise that are situate on declivities ought to be more absorbent than those in the same climate on plains or in valleys.

The productiveness of soils must likewise be influenced by the nature of the subsoil, or the earthy or stony strata, on which they rest. Thus a sandy soil may owe its fertility to the power of the subsoil to retain water; and an absorbent clayey soil may occasionally be prevented from being barren, in a moist climate, by the influence of a substratum of sand or gravel.

Those soils that are most productive of corn, contain always certain proportions of aluminous or calcareous earth in a finely divided state, and a certain quantity of vegetable or animal matter.

The quantity of calcareous earth is however very various, and in some cases exceedingly small.

Mr. Tillet, in some experiments made on the composition of soils at Paris, found, that a soil composed of three eighths of clay, two eighths of river sand, and three eighths of the parings of limestone, was very proper for wheat.

In general, bulbous roots require a soil much more sandy, and less absorbent, than the grasses.

Plants and trees, the roots of which are fibrous and hard, and capable of penetrating deep into the earth, will vegetate to advantage in almost all common soils that are moderately dry, and do not contain a very great excess of vegetable matter.

From the great difference of the causes that influence the productiveness of lands, it is obvious, that, in the present state of science, no certain system can be devised for their improvement, independent of experiment; but there are few cases, in which the labour of analytical trials will not be amply repaid by the certainty with which they denote the best methods of melioration; and this will particularly happen, when the defect of composition is found in the proportions of the primitive earths.

In supplying animal or vegetable manure, a temporary food only is provided for plants, which is in all cases exhausted by means of a certain number of crops; but when a soil is rendered of the best possible constitution and texture with regard to its earthy parts, its fertility may be considered as permanently established. It becomes capable of attracting a very large portion of vegetable nourishment from the atmosphere, and of producing its crops with comparatively little labour and expence.

Under the head of mineral analysis nothing is of so much general importance as the examination of soils, with a view to the improvement of such as are less productive, by supplying the ingredients they want in due proportions to increase their fertility.. An account of the methods to be pursued for this purpose, we shall here state.

The substances found in soils are certain mixtures or combinations of some of the primitive earths, animal and vegetable matter in a decomposing state, certain saline compounds, and the oxide of iron. These bodies always retain water, and exist in very different proportions in different lands, and the end of analytical expements is the detection of their quantities and mode of union.

The earths commonly found in soils are principally silex, or the earth of flints; alumine, or the pure matter of clay; lime, or calcareous earth; and magnesia. Silex composes a considerable part of hard gravelly soils, hard sandy soils, and hard stony lands. Alumine abounds most in clayey soils, and clayey loams; but even in the smallest particles of these soils it is generally united with silex and oxide of iron. Lime always exists in soils in a state of combination, and chiefly with carbonic acid, when it is called carbonat of lime. This carbonat in its hardest state is marble; in its softest, chalk. Lime united with sulphuric acid is sulphat of lime, or gypsum; with phosphoric acid, phosphat of lime, or the earth of bones. Carbonat of lime, mixed with other substances, composes chalky soils and marles, and is found in soft sandy soils. Magnesia is rarely found in soils: when it is, it is combined with carbonic acid, or with silex and alumine. Animal decomposing matter exists in different states, contains much carbonaceous substance, volatile alkali, inflammable aëriform products, and carbonic acid. It is found chiefly in lands lately manured. Vegetable decomposing matter usually contains still more carbonaceous substance, and differs from the preceding principally in not producing volatile alkali. It forms a great proportion of all peats, abounds in rich mould, and is found in larger or smaller quantities in all lands. The saline compounds are few, and in small quantity: they are chiefly muriat of soda, or common salt, sulphat of magnesia, muriat and sulphat of potash, nitrat of lime, and the mild alkalis. Oxide of iron, which is the same with the rust produced by exposing iron to air and wa-

ter, is found in all soils, but most abundantly in red and yellow clays, and red and yellow siliceous sands

The instruments requisite for the analysis of soils are few, A pair of scales capable of holding a quarter of a pound of common soil, and turning with a single grain when loaded : a set of weights, from a quarter of a pound troy to a grain : a wire sieve, coarse enough to let a peppercorn pass through : an Argand lamp and stand : a few glass bottles, Hessian crucibles, and china or queen's ware evaporating basins : a Wedgwood pestle and mortar : some filters made of half a sheet of blotting paper, folded so as to contain a pint of liquid, and greased at the edges : a bone knife : and an apparatus for collecting and measuring aëriform fluids.

The reagents necessary are muriatic acid, sulphuric acid, pure volatile alkali dissolved in water, solution of prussiat of potash, soap lye, and solutions of carbonat of ammonia, muriat of ammonia, neutral carbonat of potash, and nitrat of ammonia.

1. When the general nature of the soil of a field is to be ascertained, specimens of it should be taken from different places, two or three inches below the surface, and examined as to the similarity of their properties. It sometimes happens, that on plains the whole of the upper stratum of the land is of the same kind, and in this case one analysis will be sufficient. But in valleys, and near the beds of rivers, there are very great differences, and it now and then occurs, that one part of a field is calcareous, and another part siliceous ; and in this and analogous cases, the portion different from each other should be analysed separately. Soils when collected, if they cannot be examined immediately, should be preserved in phials quite filled with them, and closed with ground glass stopples. The most convenient quantity for a perfect analysis is from two hundred grains to four hundred. It should be collected in dry weather, and exposed to the air till it feels dry. Its specific gravity may be ascertained, by introducing into a phial, which will contain a known quantity of water, equal bulks of water and of the soil ; which may easily be done, by pouring in water till the phial is half full, and then adding the soil till the fluid rises to the mouth. The difference between the weight of the water, and that of the soil, will give the result. Then if the bottle will contain four hundred grains of water, and gains two hundred grains when half filled with water and half with soil, the specific gravity of the soil will be 2 ; that is, it will be twice as heavy as water : and if it gained one hundred and sixty-five grains, its specific gravity would be 1825, water being 1000. It is of importance that the specific gravity of a soil should be known, as it affords an indication of the quantity of animal and vegetable matter it contains, these substances being always most abundant in the lighter soils. The other physical properties of soils should likewise be examined before the analysis is made, as they denote, to a certain extent, their composition, and serve as guides in directing the experiments. Thus siliceous soils are generally rough to the touch, and scratch glass when rubbed upon it : aluminous soils adhere strongly to the tongue, and emit a strong earthy smell when breathed upon ; and calcareous soils are soft, and much less adhesive than aluminous soils.

2. Soils, when as dry as they can be made by exposure to the air, still retain a considerable quantity of water, which adheres with great obstinacy to them, and cannot be driven off without considerable heat : and the first process of analysis is to free them from as much of this water as possible, without affecting their composition in other respects. This may be done by heating the soil for ten or twelve minutes in a china basin over an Argand lamp, at a temperature equal to 300° F. ; and if a thermometer be not used, the proper degree of heat may easily be ascertained by keeping a piece of wood in the basin in contact with its bottom ; for as long as the colour of the wood remains unaltered, the heat is not too high ; but as soon as it begins to be charred, the process must be stopped. The loss of weight in this process must be carefully noted ; and if it amount to 50 grains in 400 of the soil, this may be considered as in the greatest degree absorbent and retentive of water, and will generally be found to contain a large proportion of aluminous earth : if the loss be not more than 10 or 20 grains, the land may be considered as slightly absorbent and retentive, and the siliceous earth as most abundant.

3. None of the loose stones, gravel, or large vegetable fibres, should be separated from the soil, till the water is thus expelled ; for these bodies are often highly absorbent and retentive, and consequently influence the fertility of the land. But after the soil has been heated as above, these should be separated by the sieve, after the soil has been gently bruised in a mortar. The weights of the vegetable fibres or wood, and of the gravel and stones, should be separately noted down, and the nature of the latter ascertained : if they be calcareous, they will effervesce

with acids; if siliceous, they will scratch glass; if aluminous, they will be soft, easily scratched with a knife, and incapable of effervescing with acids.

4. Most soils, beside stones and gravel, contain larger or smaller proportions of sand of different degrees of fineness; and the next operation necessary is to separate this sand from the parts more minutely divided, such as clay, loam, marle, and vegetable and animal matter. This may be done sufficiently by mixing the soil well with water; as the coarse sand will generally fall to the bottom in the space of a minute, and the finer in two or three; so that by pouring the water off after one, two, or three minutes, the sand will be for the most part separated from the other substances; which, with the water containing them, must be poured into a filter. After the water has passed through, what remains on the filter must be dried and weighed; as must also the sand; and their respective quantities must be noted down. The water must be preserved, as it will contain the saline matter, and the soluble animal or vegetable matter, if any existed in the soil.

5. A minute analysis of the sand thus separated is seldom or never necessary, and its nature may be detected in the same way as that of the stones and gravel. It is always siliceous sand, or calcareous sand, or both together. If it consist wholly of carbonat of lime, it will dissolve rapidly in muriatic acid with effervescence: but if it consist partly of this and partly of siliceous matter, a residuum will be left after the acid has ceased to act on it, the acid being added till the mixture has a sour taste, and has ceased to effervesce. This residuum is the siliceous part; which being washed, dried, and heated strongly in a crucible, the difference of its weight from that of the whole, will indicate the quantity of the calcareous sand.

6. The finely divided matter of the soil is usually very compound in its nature: it sometimes contains all the four primitive earths of soils, as well as animal and vegetable matter; and to ascertain the proportions of these with tolerable accuracy, is the most difficult part of the subject. The first process to be performed in this part of the analysis is the exposure of the fine matter of the soil to the action of muriatic acid. This acid, diluted with double its bulk of water, should be poured upon the earthy matter in an evaporating basin, in a quantity equal to twice the weight of the earthy matter. The mixture should be often stirred, and suffered to remain for an hour, or an hour and half, before it is examined. If any carbonat of lime, or of magnesia, exist in the soil, they will have been dissolved in this time by the acid, which sometimes takes up likewise a little oxide of iron, but very seldom any alumine. The fluid should be passed through a filter; the solid matter collected, washed with distilled or rain water, dried at a moderate heat, and weighed. Its loss will denote the quantity of solid matter taken up. The washings must be added to the solution; which, if not sour to the taste, must be made so by the addition of fresh acid; and a little solution of prussiat of potash must be mixed with the liquor. If a blue precipitate occur, it denotes the presence of oxide of iron, and the solution of the prussiat must be dropped in, till no further effect is produced. To ascertain its quantity, it must be collected on a filter in the same manner as the other solid precipitates, and heated red: the result will be oxide of iron. Into the fluid freed from oxide of iron a solution of carbonat of potash must be poured till all effervescence ceases in it, and till its taste and smell indicate a considerable excess of alkaline salt. The precipitate that falls down is carbonat of lime; which must be collected on a filter, dried at a heat below that of redness, and afterward weighed. The remaining fluid must be boiled for a quarter of an hour, when the magnesia, if there be any, will be precipitated combined with carbonic acid, and its quantity must be ascertained in the same manner as that of the carbonat of lime. If any minute proportion of alumine should, from peculiar circumstances, be dissolved by the acid, it will be found in the precipitate with the carbonat of lime, and it may be separated from it by boiling for a few minutes with soap lye sufficient to cover the solid matter; for this lye dissolves alumine, without acting upon carbonat of lime. Should the finely divided soil be sufficiently calcareous to effervesce very strongly with acids, a simple method of ascertaining the quantity of carbonat of lime, sufficiently accurate in all common cases, may be adopted. As carbonat of lime in all its states contains a determinate quantity of acid, which is about 45 parts in a hundred by weight, the quantity of this acid given out during the effervescence occasioned by its solution in a stronger acid will indicate the quantity of carbonat of lime present. Thus, if you weigh separately one part of the matter of the soil, and two parts of the acid diluted with an equal quantity of water, and mix the acid slowly in small portions with the soil, till it ceases to occasion any effervescence, by weighing the mixture, and the acid

that remains, you will find the quantity of carbonic acid lost; and for every four grains and half so lost you will estimate ten grains of carbonat of lime.

7. The quantity of insoluble animal and vegetable matter may next be ascertained with sufficient precision by heating it to a strong red heat in a crucible over a common fire, till no blackness remains in the mass, stirring it frequently meanwhile with a metallic wire. The loss of weight will ascertain the quantity of animal and vegetable matter there was, but not the proportions of each. If the smell emitted, during this process, resemble that of burnt feathers, it is a certain indication of the presence of some animal matter; and a copious blue flame almost always denotes a considerable proportion of vegetable matter. Nitrat of ammonia, in the proportion of twenty grains to a hundred of the residuum of the soil, will greatly accelerate this process, if the operator be in haste; and not effect the result, as it will be decomposed and evaporate.

8. What remains after this decomposition of the vegetable and animal matter, consists generally of minute particles of earthy matter, which are usually a mixture of alumine and silex with oxide of iron. To separate these, boil them two or three hours in sulphuric acid diluted with four times its weight of water, allowing an hundred and twenty grains of acid for every hundred grains of the residuum. If any thing remain undissolved by this acid, it may be considered as silex, and be separated, washed, dried, and weighed, in the usual manner. Carbonat of ammonia being added to the solution in quantity more than sufficient to saturate the acid, the alumine will be precipitated; and the oxide of iron, if any, may be separated from the remaining liquid by boiling it. It scarcely ever happens, that any magnesia or lime escapes solution in the muriatic acid; but, if it should, it will be found in the sulphuric acid; from which it may be separated as directed above for the muriatic. This method of analysis is sufficiently precise for all common purposes: but if very great accuracy be an object, the residuum after the incineration must be treated with potash, and in the manner in which stones are analysed, as given in the first part of this article.

9. If the soil contained any salts, or soluble vegetable or animal matter, they will be found in the water used for separating the sand. This water must be evaporated to dryness at a heat below boiling. If the solid matter left be of a brown colour, and inflammable, it may be considered as partly vegetable extract. If its smell, when exposed to heat, be strong and fetid, it contains animal mucilaginous or gelatinous matter. If it be white and transparent, it may be considered as principally saline. Nitrat of potash or of lime is indicated in this saline matter by its sparkling when thrown on burning coals: sulphat of magnesia may be detected by its bitter taste: and sulphat of potash produces no alteration in a solution of carbonat of ammonia, but precipitates a solution of muriat of barytes.

10. If sulphat or phosphat of lime be suspected in the soil, a particular process is requisite to detect it. A given weight of the entire soil, as four hundred grains for instance, must be mixed with one third as much powdered charcoal, and kept at a red heat in a crucible for half an hour. The mixture must then be boiled a quarter of an hour in half a pint of water, and the solution, being filtered, exposed some days to the open air. If any soluble quantity of sulphat of lime, or gypsum existed in the soil, a white precipitate will gradually form in the fluid, and the weight of it will indicate the proportion.

Phosphat of lime, if any be present, may be separated from the soil after the process for gypsum. Muriatic acid must be digested upon the soil in quantity more than sufficient to saturate the soluble earths. The solution must be evaporated, and water poured upon the solid matter. This fluid will dissolve the compounds of earths with the muriatic acid, and leave the phosphat of lime untouched.

11. When the examination of a soil is completed, the products should be classed, and their quantities added together; and if they nearly equal the original quantity of soil, the analysis may be considered as accurate. It must however be observed, that when phosphat or sulphat of lime is discovered by the independent process, No. 10, just mentioned, a correction must be made for the general process, by subtracting a sum equal to their weight from the quantity of carbonat of lime obtained by precipitation from the muriatic acid. In arranging the products, the form should be in the order of the experiments by which they are obtained. Thus 400 grains of a good siliceous sandy soil may be supposed to contain

	grains.
Of water of absorption	18
Of loose stones and gravel, principally siliceous	42
Of undecompounded vegetable fibres	10
Of fine siliceous sand	200
Of minutely divided matter, separated by filtration, and consisting of	
Carbonat of lime	25
Carbonat of magnesia	4

Matter destructible by heat, principally vegetable	10
Silex	40
Alumine	32
Oxide of iron	4
Soluble matter, principally sulphat of potash and vegetable extract	5
Gypsum	3
Phosphat of lime	2
	— 125
Amount of all the products	395
Loss	5
	400

In this instance the loss is supposed small; but in general, in actual experiments, it will be found much greater, in consequence of the difficulty of collecting the whole quantities of the different precipitates; and when it is within thirty, for four hundred grains, there is no reason to suspect any want of due precision in the processes.

12. When the experimenter has become acquainted with the use of the different instruments, the properties of the reagents, and the relations between the external and chemical qualities of soils, he will seldom find it necessary to perform, in any one case, all the processes that have been described. When his soil, for instance, contains no notable proportion of calcareous matter, the action of the muriatic acid, No. 6, may be omitted: in examining peat soils, he will principally have to attend to the operation by fire and air, No. 7: and in the analysis of chalks and loams, he will often be able to omit the experiment with sulphuric acid, No. 8.

In the first trials that are made by persons unacquainted with chemistry, they must not expect much precision of result. Many difficulties will be met with: but in overcoming them the most useful kind of practical knowledge will be obtained; and nothing is so instructive in experimental science, as the detection of mistakes. The correct analyst ought to be well grounded in general chemical information; but perhaps there is no better mode of gaining it, than that of attempting original investigations. In pursuing his experiments, he will be continually obliged to learn from books the history of the substances he is employing or acting upon; and his theoretical ideas will be more valuable in being connected with practical operation, and acquired for the purpose of discovery.

On the uses to which each soil may be most advantageously applied.—Clay soils, when sufficiently enriched with manures, are naturally well qualified for carrying crops of wheat, oats, beans, and clover; but are not fitted for barley, turnips, potatoes, &c. or even for being kept under grass longer than one year. Perhaps such soils ought to be regularly summer-fallowed once in six, or at the most once in eight years, even when they are comparatively in a clean state, as they contract a sourness and adhesion from wet ploughing, only to be removed by exposure to the sun and wind during the dry months of summer. Soils of this kind receive little benefit from winter ploughing, unless so far as their surface is thereby presented to the frost, which mellows and reduces them in a manner infinitely superior to what could be accomplished by all the operations of man. Still they are not cleaned or made free of weeds by winter ploughing; and therefore this operation can only be considered as a good mean for procuring a seed-bed, in which the seeds of the future crop may be safely deposited. Hence the necessity of cleaning clay soils during the summer months, and of having always a large part of every clay farm under summer fallow. All clay soils require great industry and care, as well as a considerable portion of knowledge in the dressing or management, to keep them in good condition; yet when their natural toughness is got the better of, they always yield the heaviest and most abundant crops. One thing requisite for a clay soil, is to keep it rich and full of manure; a poor clay being the most ungrateful of all soils, and hardly capable of repaying the expense of labour, after being worn out and exhausted. A clay soil also receives, comparatively, small benefit from grass; and when once allowed to get into a sterile condition, the most active endeavours will with difficulty restore fertility to it, after the lapse of many years.

Upon light soils, the case is very different. These flourish under the grass husbandry; and bare summer fallow is rarely required, because they may be cleaned and cropped in the same year, with that valuable esculent, turnip. Upon light soils, however, wheat can seldom be extensively cultivated; nor can a crop be obtained of equal value, either in respect of quantity or quality, as on clays and loams. The best method of procuring wheats on light lands, is to sow upon a clover stubble, when the soil has got an artificial solidity of body, and is thereby rendered capable of sustaining this grain till it arrives at maturity. The same observation applies to soils of a gravelly nature; and upon both, barley is generally found to be of as great benefit as wheat. The facility

with which every variety of light soil is cultivated, furnishes great encouragement to keep them under the plough, though it rarely happens, that when more than one half of such soils are kept in ploughing, the possessors are greatly benefited.

Thin clays, and peat earths, are more friendly to the growth of oats than of other grains, though in favourable seasons a heavy crop of wheat may be obtained from a thin clay soil, when it has been completely summer-fallowed, and enriched with dung. A first application of calcareous manure is generally accompanied with great advantage upon these soils; but when once the effect of this application is over, it can hardly be repeated a second time, unless the land has been very cautiously managed after the first dressing. Neither of these soils is friendly to grass, yet there is a necessity of exercising this husbandry with them, because they are incapable of standing the plough more than a year or two in the course of a rotation. When we come to that branch of our article which treats of cropping, we shall notice these matters at greater length; but in this place it may be sufficient to say, that wheat ought to be the predominant crop upon all the rich clays and strong loams, and that light soils of every kind are well qualified for turnips, barley, &c. Upon the thin and moorish soils, oats must necessarily preserve a prominent rank; and grass seeds may be cultivated upon every one of them, though with different degrees of advantage, according to the natural and artificial richness of each soil, or to the qualities which it possesses for encouraging the growth of clover, in the first instance, and preserving the roots of the plant afterwards.

We now come to that part which treats on practical agriculture.

On Tillage.—Tillage may, in general terms, be described as an operation whereby the soil is either cleared from noxious weeds, or prepared for receiving the seeds of plants cultivated by the husbandman. When this operation is neglected, or even partially executed, the soil becomes foul, barren, and unproductive; hence, upon arable farms, tillage forms the prominent branch of work; and, according to the perfection or imperfection with which it is executed, the crops of the husbandman, whether of corn or grass, are in a great measure regulated.

Tillage, in the early ages, was performed by hand labour; but in modern times, the plough has been the universal instrument used for executing this necessary and important branch of rural work. In no other way can large fields be turned over, because the expense of digging with the spade, the only other method of turning over the ground, would much exceed any profit that could be reaped. Spade-work, however, is almost universally used in garden culture, where the plants raised are of greater value than those cultivated in the fields; though the nearer that field culture can be brought to what is exercised in a garden, so much more may the practice of the art be considered as approximating in perfection to that of the other.

In a work of this kind, it is unnecessary to enlarge upon the way by which tillage may be successfully executed. It is proper to state, however, that stones lying above or below the surface are the most formidable obstruction to perfect tillage. On stony ground, the work is not only imperfectly executed, but in many cases the implement is broken to pieces, and a considerable portion of time lost before it is repaired, and put in order. The removal of stones, therefore, especially of such as are below the surface, ought to be a primary object with every agriculturist; because a neglect of this kind may afterwards occasion him considerable loss and inconvenience. In our practice we have ascertained, that rocky fields are ploughed at an expense nearly double of what was required upon others under different circumstances; because the ploughman, from necessity, is obliged to go slowly and with caution. In such situations the evil hardly admits of correction, because the substratum is almost of the same nature; and the rocks which appear may be considered in the light of excrescences from the substratum; but where single fixed stones appear in an arable field, they ought to be removed immediately, although the closeness of their texture may render the assistance of gunpowder necessary. It deserves attention, that very fine soil is always in contact with rocks of this description; and that by gaining the use of it, much benefit is derived, independent of the facility which is thus afforded to the ploughman's operations.

On the utility of Summer Fallow.—The necessity of summer fallow depends greatly upon the nature and quality of the soil; as, upon some soils, a repetition of this practice is less frequently required than upon others. Wherever the soil is incumbent upon clay, it is more disposed to get foul, than when incumbent upon a dry gravelly bottom; besides, wet soils, from being ploughed in winter, contract a stiffness which lessens the pasture of artificial plants, and prevents them from re-

ceiving sufficient nourishment. When land of a dry gravelly quality gets foul, it may easily be cleaned without a plain summer fallow; since crops, such as turnips, &c. may be substituted in its place, which, when drilled at proper intervals, admit of being ploughed as often as necessary; whereas wet soils, which are naturally unfit for carrying such crops, must be cleaned and brought into good order, by frequent ploughings and harrowings during the summer months.

A well managed fallow should be wrought as early in the season as possible, and continually turned over so long as the least particle of quickens, or weeds, appears. It is no argument against the utility of fallows, that they are often managed in a different way; this militates only against the impropriety of the management, but not against the practice itself.

The necessity of summer fallow turns upon this single point:—Can wet lands be advantageously employed in raising turnips or cabbages; a question which the practical farmer, who is sufficiently acquainted with the nature of such soils, and the immense labour required to bring them into proper tilth, will have no difficulty to answer in the negative. It is not disputed that turnips and cabbages will grow upon these soils; but the question is, whether the extraordinary labour they require, and the damage sustained by the ground, during the consumption or carrying off the crops, will not exceed the value of the produce?

As many different opinions prevail relative to the manner in which a fallow should be conducted, our sentiments upon that head may be acceptable.

Upon all clay soils (and upon such only, we understand a complete summer fallow to be necessary,) the first ploughing ought to be given during the winter months, or as early in the spring as possible; which promotes the rotting of the sward and stubble. This should be done by gathering up the ridge, which both lays the ground dry, and rips up the furrows. As soon as seed-time is over, the ridge should be cloven down, preparatory to cross ploughing; and, after lying a proper time, should be harrowed and rolled repeatedly, and every particle of quickens that the harrows have brought above should be carefully picked off with the hand. It is then proper to ridge or gather it up immediately, which both lays the land in proper condition for meeting bad weather, and opens up any fast land that may have been missed in the furrows when the cross ploughing was given. After this, harrow, roll, and gather the root weeds again; and continue so doing till the field is perfectly clean.

Considering how much weeds prevail in our fields, and how difficult it is, even for the most attentive farmers, to prevent their crops being hurt by them, frequent fallowing, as the most proper method of destroying these enemies, cannot be too much recommended. When we have arrived at greater perfection in the several operations of agriculture, and brought our lands to a higher degree of fertility than at present, then, and, indeed, in my opinion, not till then, should we think of introducing schemes of perpetual cropping.

A mode of executing summer fallow, and procuring a crop of turnips in the same year, comes now to be noticed. In this way the land may be completely cleaned, perhaps more so than by a bare fallow; but it is only on light dry soils, that such a mode of cleaning is eligible, or can be executed with advantage.

The second object of tillage is to prepare the ground for receiving the seeds of plants cultivated by the husbandman; and here, in general, it may be remarked, that the object is most completely accomplished, when the ground is ploughed deep and equal, while the bottom of the furrow immediately above the subsoil is perfectly loosened, and turned equally over with the part which constitutes the surface. In many places, these properties are altogether neglected, the ground being ploughed in a shallow way, while the bottom of the ploughed land remains something like the teeth of a saw, having the under part of the furrow untouched, and consequently not removed by the action of the plough. While these things are suffered, the object of tillage is only partially gained. The food of plants (whatever it may be,) can only be imperfectly procured; and the ground is drenched and injured by wetness; these bridges, or pieces of land, which are not cut, preventing a descent of the moisture from above to the open furrows left for carrying it off. Where the seed-bed is prepared by one ploughing, the greatest care ought to be used in having it closely and equally performed. When two are given, they should be in opposite directions, so that any firm land left in the first may be cut up in the second ploughing. It is not profitable to plough twice one way, if it can be safely avoided.

Another important point, towards procuring good tillage, is never to plough the land when in a wet state; because encouragement is thus given to the growth of weeds, while a sourness and adhesion is

communicated to the ground, which is rarely got the better of till the operations of a summer fallow are again repeated. The Roman writers are very particular against ploughing land, when wet. It is reprobated, in fact, by every one of them. Columella justly represents wet ploughing as most dangerous to the ground:—"When we plough," says he, "we must not touch wet land; for the fields, which are ploughed wet, cannot be touched for the whole year, and are fit neither for being sown, harrowed, nor planted." From this passage, it appears, that it was reckoned particularly dangerous to give the fallow the first ploughing when in a wet state; and that, when this was done, it was impossible, by any operations afterwards, to bring it to a right tilth that seed-time.

Before we finish this, it is proper to remark, that all such soils ought not to be wrought, or ploughed, in one manner. Each kind has its particular and appropriate qualities; and therefore, each requires a particular and appropriate mode of tillage. Ploughing, which is the capital operation of husbandry, ought, on these accounts, to be administered according to the nature of the soil which is to be operated upon, and not executed agreeably to one fixed and determined principle. On strong clays and loams, and on rich gravels and deep sands, the plough ought to go as deep as the cattle are able to work it; whereas, on thin clays and barren sands, the benefit of deep ploughing is very questionable, especially when such are incumbent on a till-bottom, or where the subsoil is of a yellow ochre nature; such, when turned up, being little better than poison to the surface, unless highly impregnated with alluvial compost, the effect of which expels the poisonous substances contained in this kind of subsoil, and gives a fertility to the whole mass, more decisive and permanent than would follow a heavy application of the best rotten dung.

On clay soils, where the ridges must be considerably acclivated, so that the ground may be preserved in something like a dry condition, the plough, used for tillage, ought to have a mould-board considerably wider set than is required for light soils, in order that the furrow may be close cut below, and duly turned over. This method of constructing the plough necessarily makes a heavier draught than would be the case were the mould-board placed differently, though, if good and sufficient work be wanted, the necessity of constructing the implement in the way mentioned, is absolute and indispensable. The plough to be used on light soils, or on all soils that admit what is technically called crown and furrow ploughing, may be made much straiter below, and yet be capable of executing the work in a perfect manner. Perhaps on every farm consisting of mixed soils, two sets of ploughs ought to be kept, otherwise proper work cannot be performed. All land ought to be ploughed with a *shoulder*, a phrase well understood by ploughmen, though not easily explained; and the advantages of ploughing in this way are, that, if ploughed before winter, the surface is enabled to resist the winter rains, and afterwards to present a face, on which the harrows can make a proper impression, when the seed process is to be executed. This deserves particular attention when old grass fields are to be broken up; as, by neglecting it, the harrows often are unable to cover the seed. It is perfectly practicable to plough land with a tolerably broad furrow, say 10, 11, or 12 inches, and yet to plough it clean, provided the implement used is properly constructed; but, then, care must be taken that the furrow be of proportional deepness, otherwise it will be laid on its back, instead of being deposited at an angle proper for undergoing the harrowing process.

On manures.—The term *manure* is applied indiscriminately to all substances, which are known from experience either to enrich the different soils, or contribute in any other way to render them more favourable to vegetation.

Though little doubt can be entertained of the utility and necessity of such substances, yet the progress hitherto made, in ascertaining the mode in which they ought to be applied, the quantity that should be made use of, and the soils for which they are respectively best adapted, has not yet reached that perfection or certainty that could be wished.

The most superficial observations will serve to convince any intelligent person, that, in an agricultural point of view, the subject of manures is of the first magnitude. To correct what is hurtful to vegetation in the different soils, and to restore what is lost by exhausting crops, are operations in agriculture which may be compared to the curing of diseases in the animal body, or supplying the waste occasioned by labour, or the ordinary evacuations of nature.

The utility of manuring has, however, been questioned in some instances, particularly by *Tull* and his disciples, who assert, that *tillage alone*, frequently and judiciously applied, will produce every effect that can be expected from that practice.

That tillage is essential to the success of agricultural operations, is a point in which all good husbandmen are agreed; but that, by tillage alone, the earth should be made to produce a succession of valuable crops of grain or vegetables, is a doctrine, which, fortunately for the advancement of agriculture, has met with very few converts. By such management poor lands would never become productive, and the richest soils would soon be exhausted.

Another opinion has been held forth to the public, that when land has once been put into good heart, it may be preserved in a state of constant fertility, merely by a proper *rotation of crops*, without any foreign manure.

We need not extend our observations upon this subject farther; for a good farmer, who wishes to avail himself of every advantage which experience points out, will, to a certain degree, adopt, 1st, *The tillage recommended by Tull*, for the purpose of pulverizing the soil, and extirpating the weeds with which it may be infested; 2d, *A regular rotation of crops*, in order that the various sorts of earth may, in their turn, according as they are calculated for different plants, become productive; and, 3d, *Endeavour to gather a sufficient quantity of manure*, not only to prevent the soil from being exhausted, but, if possible, annually to make some addition to its former sources of fertility.

On the Management of Dung.--Manure, being the first requisite of good husbandry, it shall be our business, in this Section, to speak in a particular manner of the best methods of collecting, preparing, and applying that portion of it called *farm yard dung*, which, in most instances, may be considered as the chief manure used by the great body of husbandmen.

The most superficial observer in rural economics must have often noticed, that a considerable number of practical agriculturists are inattentive, not only to the gathering of the raw materials, but also defective in the several steps of preparatory process, before dung can be thriftily and suitably applied. With such, very little care is used in cutting the corn crops, which, properly speaking, is the only source whence raw materials can be got. They are also too apt to dispose of any hay which may be raised upon their farms, even when prices are not so high as to tempt a breach of good husbandry. They often keep more beasts on the premises than is consistent with the quantity of provender in hand, thus reducing the stock of manure in an extraordinary degree. Besides, seldom is any care bestowed in laying up the dung, in a regular and careful way, during the winter months, and still less upon its state during the exhausting spring winds, or the parching heat of the summer months. Instead of storing it up with regularity, and mixing the different kinds in a compact heap, it is suffered to remain as tossed from the stable; continues exposed, in its rough state, to the weather; often inundated with water, and rarely touched till the cart arrives to drive it to the field.

As straw is the basis of manure, it might be expected that every good husbandman would bestow the most sedulous attention upon the shearing or cutting of his crop, so that the greatest possible quantity of the raw material may be procured. Very different, however, is the conduct of farmers in general; as it may be safely estimated, that at least one-half of the straw is left in the field, where its strength is wasted and dissipated by the rains and storms that commonly prevail at the conclusion of autumn. In some districts a stricter attention is now paid to this important operation, and it is to be hoped that such an improvement will gradually extend. Independent of the additional grain which is gained, the increase of manure will more than compensate the increased expense of gathering the crops in an accurate manner.

By a steady perseverance in this practice, from one to two tons of manure (per acre) may be annually gained, especially where the crops are good. This annual increase must operate powerfully upon the improvement of the country, the effects being precisely similar to to those of adding compound interest

The usual modes of converting straw into dung, hardly require to be mentioned. A good deal is consumed in the house by draught horses and milch-cows; and the remainder is used by lean cattle, kept in the fold-yard. Though these are the general methods of consumption, it will be necessary to divide the subject into two parts, viz. The management of dung upon light lands, and heavy lands; because manure on each is prepared in different ways, used in different seasons, and applied to different crops. For light soils, manure requires to be much more highly prepared than is necessary for clay soils; and every step of the previous preparation, in order to be perfect, ought to be executed in a quite different manner.

For soils of the first description, where turnips are taken as a first crop, dung can hardly be too well prepared; because the

nature of the crop to which it is applied, renders a complete incorporation with the ground absolutely necessary; without which the young plants might be starved at their very entrance into life. In the best farmed districts, which have come under our observation, dung is often kept more than a year, in order that it may be perfectly rotted. Management of this kind, however, cannot be approved of, for if the preparatory steps are conducted with judgment, there is rarely any necessity for keeping dung over the year; besides, such a delay causes a waste of the article, and serves to dissipate its strength: at all events, a year's interest of the value of the increased produce must be lost. In general cases there is not much difficulty in preparing dung; because, in the driest season, from the nature of the food used, such a quantity of liquid passes from the animals, as to prevent burning, the greatest obstacle to the rotting of dung that can be experienced. If dung is regularly removed, if it is properly mixed with the horse litter, and other excrementitious matter accumulated upon the farm, it will be found an easy task to prepare all that is made by the middle of April; at which time the fold-yard should be cleared. What is produced after that time should be stored up separately; receive waterings, if the weather is dry, and be reserved for clover-stubbles, or other fields that are to be dunged in autumn.

The middle of April is mentioned as a good time for clearing the fold-yard; but this does not prevent the work from going partially forward through the winter, when suitable opportunities occur. When driven out of the fold-yard, the dung should be laid up in a regular heap or pile, not exceeding four feet and an half in height; and care should be taken not to put either horse or cart upon it, which is easily avoided, by backing the cart to the pile, and laying the dung compactly together with a grape or fork. It is also useful to face up the extremities with earth, which keeps in the moisture, and prevents the sun and wind from doing injury. Perhaps a small quantity of earth strewed upon the top might also prove useful. Dung, when managed in this manner, generally ferments very rapidly; but if it is discovered to be in a backward state, a complete turn over, about the first of May, when the weather becomes warm, will quicken the process; and the better it is shaken asunder, the sooner will the object in view be accomplished.

A secluded spot of ground, not much exposed to wind, and perfectly secure from being floated with water, ought always to be chosen for the scite of such piles or heaps. If the field, to which it is to be applied, is at hand, a little after-trouble may be saved by depositing it there in the first instance: But it is found most convenient to reserve a piece of ground adjacent to the homestead for this purpose. There it is always under the farmer's eye, and a greater quantity can be moved in a shorter time than when the situation is more distant. Besides, in wet weather, and this is generally the time chosen for such an operation, the roads are not only cut up, by driving to a distance, but the field, on which the heap is made, may be poached and injured considerably.

The above is the most approved method of preparing dung upon light land farms; and a few words shall now be said respecting the management necessary upon those of a different description.

Upon clay soils, the rotting of dung is not only a troublesome, but an expensive affair. Independent of what is consumed by the ordinary farm-stock, the overplus of the straw must somehow or other be rotted, by lean cattle kept in the fold-yard, who either receive the straw in racks, or have it thrown across the yard, to be eaten and trodden down by them. According to this mode of consumption, it is evident that a still greater necessity arises for a frequent removal of this unmade dung: otherwise, from the trampling of beasts, and the usual want of moisture, it would compress so much as altogether to prevent putrefaction. To prepare dung sufficiently upon farms of this description, is at all times an arduous task, but scarcely practicable in dry seasons; for if it once gets burnt, it is almost physically impossible to bring it into a suitable state of preparation afterwards; and, at all events, its virtues are thereby considerably diminished. To prevent such an injury, no measure can be so successfully used, as a frequent removal of this unmade dung, especially if the weather is wet at the time. If people can stand out to work, there cannot be too much wetness when executing this operation: for there is always such a quantity of the straw that has not passed through the entrails of the cattle, as renders it almost impossible to do injury, in the first instance, by an excess of moisture.

It is therefore recommended, upon every clay-land farm, especially those of considerable size, that the fold-yard be frequently cleared; and that the greatest care be taken to mix the stable or horse dung in a regular way with what is gathered in the fold-yard, or made by other animals, in order that a gradual heat or fermentation may be speedily produced.

The heap or pile, as already recommended, in the first preparation of dung, should be formed in a secluded spot, if such can be got at hand; because the less it is exposed to the influence of the sun and wind, so much faster will fermentation proceed. It should be constructed on a broad basis, which lessens the bounds of the extremities; and several separate heaps are necessary, so that too much may not be deposited at once; which, to a certain extent, would bring on the very evil we have all along been endeavouring to avert. By shifting the scene frequently, and allowing each covering or coat to settle and ferment, before laying on any more, the most happy effects will follow, and these heaps (at least all such as are completed before the first of May,) may reasonably be expected to be in a fit condition for applying to the summer fallow fields, in the end of July, or first of August. If the external parts get dry at any time during the process, it will be proper to water them thoroughly, and in many cases to turn over the heap completely. It may be added, that much benefit has been experienced from laying a thick coating of snow upon such heaps, as, by the gradual melting thereof, the whole moisture is absorbed, and a strong fermentation immediately follows.

The same method of management may be continued during the summer months, so far as circumstances permit, though it rarely happens that dung collected at this advanced period is fit for use in the same season, unless it be such as is made by keeping horses and cattle in the house upon green food. Perhaps, as a general principle, it is proper to thrash out all grain before summer arrives, (a small quantity for litter and other necessary purposes excepted,) in order that the full value of the raw materials, when converted into manure, may be gained.

Upon large farms, where the management of manure is sufficiently understood and practised, it is an important matter to have dunghills of all ages, and ready for use, whenever the situation of a field calls for a restorative. No method of application to clay soils, however, is so beneficial as during the year of summer fallow, though, in such situations, a greater stock of manure is often gathered than is required for the fields under this process.

It likewise deserves attention, that dung applied to a clay fallow at the end of summer, has full time to incorporate with the ground, before the crop, sown thereupon, stands much in want of its invigorating support; consequently, though of apparently inferior quality at the time of application, may, in reality, be possessed of equal powers for fructifying the ground, as if it had reached a higher state of preparation.

We may now notice some instances, respecting the management of manure, where grass husbandry is extensively practised. In these districts, it is very common to use a considerable proportion of their hay in the fields, during the winter months, instead of consuming it in the house or fold-yard, where the manure produced could readily be collected, and properly managed. Sloth and waste are the parents of this custom; a custom which ought to be interdicted by every proprietor who is disposed to regard either his own interest or that of the country; much of the article being absolutely rendered useless by the feet of the beasts so maintained, while the ground is most unequally and partially dunged; that is to say, the richest and driest parts are sure to receive the greatest store.

Some remarks relative to the application of dung, a subject of as much importance as the collecting and preparing of it, shall now be offered.

These are, that no greater quantity ought to be given at one time than is sufficient to fructify the ground; in other words, to render it capable of producing good crops, before the time arrives when a fresh dose can be administered. The errors of former times consisted in giving too great a quantity at once, thereby depriving the ground of its regular nourishment; in other words, the soil rioted in the midst of plenty for two or three years, and fasted and starved for several succeeding ones. Hence the generality of fields were either too rich, or too poor; either saturated with manure, or completely barren from the want of it; whereas, had supplies been furnished in an œconomical manner; had the quantity of manure on hand been distributed with judgment, a more uniform produce would have been the consequence. The new system of applying manure corrects all these errors, in so far as local circumstances will permit. Accordingly, a small quantity is now bestowed at once, and the dose frequently repeated. The ground is regularly fed; but never surfeited with a profusion. Hence the crops constituting a regular rotation are more uniformly good, and a greater proportion of the valuable grains are raised, than could be accomplished in former times.

Though land can rarely be rendered too rich for carrying green crops, yet it is well known that the same observation will

not hold good when applied to wheat, barley, and oats; but that such may be, and often have been, materially injured in consequence of heavy manuring.

Another general remark occurs; that is, concerning the utility of spreading dung with accuracy; in other words, dividing it into the minutest particles, thereby giving every part of the ground an equal supply of food. This practice was miserably neglected in former times, and is still less attended to than its importance deserves.

The principal object to be attended to, is an allotment of the manure collected upon the premises, in such a way as that the greatest possible return over the whole farm, not from a particular field, may be gained by the occupier.

It remains only to be stated, that many arable farms, under the strictest œconomy, are unable to furnish supplies for an intermediate dunging, at least to its full extent; but persons so circumstanced have it always in their power to overcome this defect, and preserve a regular rotation, by keeping certain fields longer in grass; which, of course, will yield weightier crops when broken up, and stand less in need of manure during the after rotation. By such arrangements, made according to circumstances, it is an easy matter to preserve a regular rotation, and to proportion the corn crops to the quantity of manure collected upon the premises.

We may add, that the practice of soiling or feeding horses and cattle in the house or farm-yard, is eminently calculated to increase the quantity of manure upon every farm, and to improve its quality.

The soiling of horses, in the summer months, on green clover and rye-grass, is a practice which prevails in every corn district where farm labour is regularly executed. The utility of the practice does not need the support of argument; for, it is not only œconomical to the farmer, but saves much fatigue to the poor animal: besides, the quantity of dung thereby gathered is considerable.

Of Compost Middens.—The use of manure in the shape of compost, or ingredients of various qualities, mixed together in certain proportions, has long been a favourite practice with many farmers; though it is only in particular situations that the practice can be extensively or profitably executed. The ingredients used in these composts are chiefly earth and lime; sometimes dung, where the earth is poor; but lime may be regarded as the main agent of the process, acting as a stimulus for bringing the powers of the heap into action. Lime, in this view, may be considered as a kind of yeast, operating upon a heap of earth as yeast does upon flour or meal. It is obvious, therefore, that unless a sufficient quantity is given, the heap may remain unfermented; in which case little benefit will be derived from it as a manure.

The best kind of earth for compost is that of the alluvial sort, which is always of a rich greasy substance, often mixed with marl, and in every respect well calculated to enrich and invigorate barren soils, especially if they are of a light and open texture. Old yards, deep headlands, and scourings of ditches, offer themselves also as the basis of compost middens; but it is proper to summer fallow them before hand, so that they may be entirely free of weeds. When the lime is mixed with the soil of these middens, repeated turnings are necessary, that the whole may be suitably fermented; and some care is required to apply the fermented mass at a proper time to the field on which it is to be used.

The formation and conveyance of compost being expensive, it becomes an important object to save labour in the previous steps of preparation, and in the concluding one of applying it to the soil. The first part of the object is gained by using horse instead of manual labour, when the lime is incorporated with the earth, and when the after turnings are bestowed; and the other is lessened considerably when the compost is laid on a field adjoining the one where it is prepared.

A few words may be necessary with respect to the quantity of lime required to produce a suitable fermentation, though here we can at best but speak at random, because the proper quantity falls to be regulated by the nature of the earth which is meant to be used as the basis of the future compost. As the quantity of the compost to be afterwards applied to the soil must, however, be ascertained by its quality, and as sixty cubic yards of alluvial compost may be viewed as containing the same portion of nutritive substance, as one hundred yards of headlands and ditch scourings, we shall assume eighty yards as a medium dose for an acre of ground, and from this datum endeavour to fix the quantity of lime that is required. From trials that have been frequently made, it appears, that two bushels of lime shells, will sufficiently ferment a cubic yard of earth of a medium quality; therefore, that one hundred and sixty bushels of lime shells are required to ferment compost for an acre of ground, where the basis con-

sists of ordinary materials. This goes upon the supposition that an admixture is regularly conducted, and that eighty cubic yards of the compost is sufficient to impregnate or enrich the field on which it is to be applied.

The benefit of such a compost in nourishing soils is even greater than what is gained by dressing them with dung; though it is to be regretted, that it rarely happens, where such soils are predominant, that materials, such as we have recommended, can be procured in any quantity.

Of Lime.—Lime has been regarded by some as a manure, by others as a stimulus, which can only be profitably applied where the soil possesses some dormant principle of fertility that needs to be roused into action. In fact, the *modus operandi* of lime is imperfectly understood, though the greater part of agriculturists seem pretty well acquainted with its effects. It is sufficiently understood, that land which has been long in grass, contains much vegetable matter, and that the trouble and expense of liming it will be amply repaid to the cultivator; but the propriety of applying lime on old arable lands has been questioned, and with much justice, by the most part of practical agriculturists, and their doubts on that head are confirmed by the fullest experience. If lime were a manure, then it would be a noble substance for enriching and restoring fertility to lands that were worn out by a succession of corn crops; bus as worn out land is not restored to fertility by the application of lime, we are warranted to rank it in a different class, or, to speak more correctly, as an article calculated to bring certain principles into action, which were previously possessed by the soil. This conclusion is sanctioned by experience; and experience is a far better guide than the most plausible theory.

Lime has been used with very great success, both in the United States and Great Britain, though it is evident that the grossest errors have been committed in the after management of land to which lime has been applied; and, what is worse, that the extent of these errors was in direct proportion to the effect produced upon the soil by the application. This remark applies more to the former state of husbandry than to the present practice, because the former rule was to crop so long as the earth would make a good return, without considering that a field, so treated, was not to be recovered for a century afterwards. Indeed, when lime duly operates, the whole powers of the soil are put in a state of requisition, and may be forced to act till the very soul of vegetation is extracted. It is scarcely practicable to restore fertility to land, even of the best natural quality, which has been thus abused; at least a considerable period must elapse before it can be restored to its original fertility; but thin moorish soils, after being exhausted by lime, are not to be restored. To lime them a second time, is not only an useless expenditure of labour and money, but also productive of serious mischief. Soils of this description, after a second liming, are apt to singe and burn the grain that is sown upon them, and even when dunged, not to make such a return as would have been rendered under different circumstances.

From a pretty long experience, and considerable attention to the operation of lime, we are inclined to think, that it acts both as an alterative and a stimulant, operating in the one case as a medicine, that changes the nature of the soil, and in the other, as rousing, or bringing into action, the vegetable powers contained in the soil, which, without such an application, would have remained dormant and inactive. These opinions, we know, are different from what have been maintained by several ingenious men on the subject; but they are supported by the result of numerous trials, undertaken to ascertain how, and in what manner, lime operated upon the soil, and whether it could be used in an hot state with the most advantage. On these points, theoretical writers are apt to fall into mistakes; and therefore every theory not formed from facts, must be viewed as a romance which may amuse, but cannot instruct agriculturists. See *Memoirs of the Agricultural Society of Philadelphia*, and the *Archives of Useful Knowledge*.

Gypsum or Plaster of Paris, is a native combination of calcareous earth with vitriolic acid. There are various species of gypsum found both in Europe and America. That mostly used in the United States comes from the Bay of Fundy, though considerable quantities are procured from the interior of the States of Pennsylvania and New York.

The uses of gypsum are very extensive; when it is sufficiently compact it is employed by the architect for columns and other ornaments, being easier to work than marble; it is also turned by the lathe into cups, basons, vases, and other similar articles. When exposed to a low red heat it parts with its water of crystallization, is converted to a fine powder called plaster of Paris, like meal; and this, when beaten up with water to the consistence of paste, shortly after sets and becomes solid; hence it is largely used for taking casts of vari-

ous magnitude, from a medal to a colossal statue; it enters into the composition of many cements; and within these few years, has also become an article of great importance in fertilizing soils. It is difficult to determine what quantity per acre will produce the best effects, as so much depends on accident of weather, &c. which cannot be calculated with any certainty; but in general, as great effect has been produced by two bushels per acre, as from any larger quantity. Indeed, there appears to be a certain point in the operations of plaster, which is not gained by additional quantity so much as by a combination of extraneous circumstances, difficult to trace or account for. The time and methods of applying it are different; on grass land it is sowed at all seasons of the year, though perhaps April or May is the most suitable time. On arable lands it is frequently sowed after the last harrowing or with the seed, but its effect is undoubtedly the greater when it is scattered amongst the plants. And the morning, while the dew prevails, or on the prospect of rain should be preferred for the purpose. Every other year is sufficient to resort to the use of gypsum, though some prefer to distribute half the quantity annually. The loamy, dry and sandy soils are the most suitable for it. On clay land or near the sea it does not succeed.

Plaster is sufficiently fine when ground to produce 20 bushels to the ton, if it is finer it is subject to fly away in strewing. It should always be remembered that calcination, however necessary it may be to make cement of plaster, lessens, if not destroys its agricultural uses. To try the quality of plaster, heat a small quantity of it pulverised, in a pot over a brisk fire: if the effervescence of a sulphureous smell be considerable it is good, if it be small it is less valuable, and if it remains inert like sand it is worth nothing. When the soil is suitable gypsum is applied with very great advantage to every species of agricultural vegetation; but as the limits of this work will not permit a more detailed account of the uses of this very important manure, the reader is referred to a work by *Judge* Peters, entitled *Agricultural Enquiries on Plaster of Paris;* also to the *Domestic Encyclopedia.*

On Marl.—Marl, like lime, may be viewed as a stimulant, forcing the soil to produce crops of corn and grass, which otherwise would not have been obtained.

The value of land has been much augmented by the application of marl. Treating of this article in a practical way, it may be divided into shell-marl and earth-marl. Shell-marl is composed of animal shells dissolved; earth-marl is a fossil. The colour of the latter is various; white, black, blue, red, and its hardness is as various as its colour; being sometimes soft and ductile like clay, sometimes hard and solid, like stone, and sometimes it is extended into thin beds, like slate. Shell-marl is easily distinguished by the shells, which always appear in it; but the similarity betwixt earth-marl and many other fossil substances, renders it difficult to distinguish them.

Shell-marl is very different in its nature from clayey and stone marls, and, from its effects upon the soil, is commonly classed among the animal manures. The Rev. Mr. Dickson states, "That it does not dissolve with water, as the other marls do. It sucks it up, and swells with it like a sponge. But the greatest difference, betwixt the shell-marl and the other marls, consists in this; the shell-marl contains oils. It is uncertain, if the other marls contain any oils.

This marl, it would seem, from the qualities which it possesses, promotes vegetation in all the different ways. It increases the food of plants; it communicates to the soil a power of attracting this food from the air; it enlarges the pasture of plants; and it prepares the vegetable food for entering their roots.

The shelly sand, often found deposited in beds in the crevices and level parts of the sea coasts, is another substance capable of being employed, both as a manure and stimulant, not only on account of its containing calcareous matter in greater or less proportions, but also from the mixture of animal and vegetable substances that are found in it. The portion of calcareous matter, contained in these substances, must vary according to circumstances; but, when the quantity is any way large, and in a reduced or attenuated state, the quality is so much the more valuable. On that account, the quantity, which ought to be applied to the soil, must be regulated entirely by the extent of calcareous matter, supposed, or found upon trial, to be contained in the article, which, as already said, is very variable.

The clayey and stone marls are distinguished by their colours; viz. white, black, blue, and red. The white, being of a soft crumbly nature, is considered to be the best for pasture land; and the blue, which is more compact and firm, for corn land. In the districts where marl is much used, these distinctions of management are attended to, though either of the kinds may be employed with advantage, if the following rules are adhered to.

If marl is of the blue kind, or of any

kind that is compact and firm, lay it upon the land early in the season, so as the weather may mellow it down before the last plough; and, if on pasture land, let it also be early laid on, and spread very thin, breaking any lumps afterwards which are not completely separated by the first spreading. If marl is of the white, or any of the loose or crumbling sorts, it need not be laid on so early; because those varieties break and dissolve almost as soon as exposed to the weather.

There are many kinds of impure and mixed marls, such as sandy, clayey, loamy, and stony marls, according as these varieties of soil are incorporated or mixed with the principal substance. These sorts, of course, are inferior to the pure marls; but the stony kind is considered to be the best, because its efficacy is more lasting, though the fat and crumbling kinds enrich or operate more speedily. The hard marls, however, in every case, operate for the greatest length of time, and are often followed with bad consequence to the soil, unless good management, with regard to cropping, is exercised during the period of their operation. After being long excessively fruitful and productive, the soil will gradually become so sterile and barren as scarcely to be worth cultivating; in which case, the greatest exertion can hardly procure a return of fertility. In this respect, the effect of over-cropping land, that has been marled, is precisely the same as takes place with lime. An uncommon exertion is made, occasioning a proportionable debility, though, were good husbandry studiously practised, the exertion would neither be so excessive, in the first instance, nor the after-consequences so mischievous. In numerous instances, land has been reduced so much, as to be thought little better than useless, by the effects of lime and marl. Both, however, are excellent agents in forwarding agriculture, though often their agency has been misapplied, and used for mischievous purposes. Under a correct rotation of cropping, and with a suitable supply of dung, neither lime nor marl is injurious. Reverse these circumstances, and the contrary effect must necessarily be produced

As marl possesses, properly speaking, certain distinctive characters, some caution is necessary in distinguishing earthy manure. Thus, in some parts of New Jersey, an earth, which is considerably blended with oxyd of iron, and which is found useful as a manure, has received, though very improperly, the name of marl. Specimens of the various kinds of earthy manure were sent me by Dr. Holcomb of Allentown, New-Jersey, which on examination, proved to be nothing more than argillaceous earth combined with oxyd of iron. In a soil, where the siliceous ingredient predominates, as in some districts of New Jersey, argil itself would be an excellent manure; hence it is, that the earth just noticed, has been used with so much success. In some districts of that state, as near the sea coast, shell marl has been discovered. This variety of marl, it may be proper to add, has been found in other places in this country. Some writers, as we have just observed, consider only two varieties or species of marl; the one consisting of clay divided by a very fine fuller's earth; the other of clay divided by calcareous earth. The presence of the latter earth, if combined with carbonic acid, which is always the case when found, is the cause of the effervescence on the addition of an acid: this effect is uniformly a criterion of calcareous marl.

The English farmers distinguish five sorts of marl: 1. The coroshut marl, which is brown mixed with fragments of chalk and blue veins. 2. Stone, slate, or flag marl: it resembles blue slate, and crumbles easily when exposed to the air. 3. Pont marl, or delving marl; it is brown, and rough to the touch. 4. Clay marl: which contains much clay. 5. Steel marl: its colour is black, its consistence like that of bits of paper.

On Sea-weed.—Sea-weed, a plant that grows upon rocks within the sea, is driven ashore after storms, and is found to be an excellent article for manuring light and dry soils, though of little advantage to those of a clayey description. This article may be applied on the proper soil with advantage to any crop, and its effects are immediate, though rarely of long continuance.

Sea-weed is applied at all seasons to the surface, and sometimes, though not so profitably, it is mixed with unrotten dung, that the process of putrefaction may be hastened. Generally speaking, it is at once applied to the soil, which saves labor, and prevents that degree of waste, which otherwise would necessarily happen. Sea-weed is, in one respect, preferable to the richest dung; because it does not produce such a quantity of weeds. Some have thought, that the weeds upon land, which has received dung, are produced by seeds mixed with the dung; but it is reasonable to presume, that the salts contained in sea-weed, and applied with it, may be the real cause of the after cleanliness. This may be inferred from the general state of coast-side lands, where sea-

weed is used. These lands are almost constantly kept in tillage, and yet are cleaner and freer from weeds, than those in inland situations, where corn crops are not so often taken.

Clay soils are not so much benefited by sea-weed, as those of a light nature; therefore, when a coast-side farm contains mixed soils, the best management is exercised, by applying sea-weed to dry, and dung to clay land. In this way, the full advantage of manure may be obtained, and a farm so circumstanced is of infinitely greater value, with respect to manuring and labouring, than one which contains no such variety.

On paring and burning the Surface, and using the Ashes as a Manure.—The practice of burning the surface, and applying the ashes as manure, to the soil that remains, has been long prevalent; and though it has been condemned, nay reprobated by many writers, and prohibited in numerous instances by proprietors, yet, by professional people, who judged of the utility of the practice, from the nature and consequences of its effects, it has, almost in every case, been supported, and considered as the most advantageous way of bringing in and improving all soils, where the surface carried a coarse sward, and was composed of peat-earth, or other inactive substances. The burning of this surface has been viewed as the best way of bringing such soils into action; the ashes, furnished by the burning, serving as a stimulant to raise up their dormant powers, thereby rendering them fertile and productive in a superior degree, than could otherwise be accomplished.

What we have said relates to what is generally called paring and burning; that is, paring the surface to the deepness of one, two, or three inches, gathering it into heaps, and burning it. We shall now speak of ashes burnt and used in a different manner; that is, when peat-earth is digged and burnt in quantities, and afterwards applied to a field of a different sort of soil or quality. The effects of ashes, used in this way, are precisely the same with those of lime, though their operation is more violent and therefore sooner over. The first crop is commonly very luxuriant; but, unless dung is afterwards administered, the soil will be rather exhausted than enriched by the application of the ashes.

On Chalk.—Chalk is used to great advantage as a manure on some wet, stiff soils having no calcareous earth; in quantity, from fifty to eighty cart-loads per acre. Its beneficial effects are said to last twenty years.

There are many soils, however, where chalk is in plenty, which derive no benefit from it. Some farmers, from observing the beneficial effects of chalk as a manure at other places, have been tempted to use it on their lands; where it has proved to be of no kind of use, and much time and expence have been entirely thrown away.

The best method of using it, is to spread it early in the autumn, in order that it may be thoroughly drenched with rain, and that the frost may have its full operation upon it; by which means it is well pulverized when the thaw comes on, and will mix the more readily with the soil.

Old grass-lands on wet sandy or clayey soil, over-run with furze or rushes, are greatly improved by chalk.

But it is to be observed, that land once completely chalked, after its fertilizing powers appear to be exhausted, is reckoned to be inferior to land that never was chalked.

Could *bone dust* be procured in sufficient quantity, and at a reasonable price, few substances would be more advantageous as a manure. Its effects upon the soil, though not immediately apparent, are in the highest degree beneficial; and their durability does not constitute the least portion of their value.

The application of *sand* as a manure is of the greatest advantage in many respects. When there is a piece of strong clay land in tillage, and the farmer has an opportunity of covering it over with sand, about twice as thick as in a common set of manure, the soil will be pulverized and opened by this means, will give better crops when in tillage, and, when laid down, will produce a finer herbage, less liable to be parched in dry, or trod down in wet seasons. It is excellent management in the farmer, before he ties up his cattle for the winter, to lay a coat of sand, at least a foot in thickness, where he intends to throw his dung out of the cow-houses. The dung should be repeatedly levelled on the sand, and a second coat of the latter laid on toward the end of February; upon which should be put the remainder of the dung procured before the cattle go to grass. As soon after this time as possible, the compost should either be turned, and mixed well where it lies; or cut down *in breasts*, filled into the dung carts, and taken away to some situation near the land on which it is intended to use it. Here it should be laid in a heap of at least two yards in thickness. After remaining two or three months in this state, it is in excellent condition for putting upon the land; and will be found, upon the whole, one of the most advantageous manures

the farmer can employ, particularly on soils where there is a considerable predominance of clay.

Coal-ashes are a good manure, but not much used, on account of their consumption in the manufacture of bricks. They are sown on the land in the spring, at the rate of four or five chaldrons per acre. Cold, wet, clay meadows are much improved by them.

Soot is a valuable manure for a top-dressing on sainfoin, clover, lucerne, and meadows: it is usually sown on the land at the rate of forty or fifty bushels per acre, early in the spring.

Though various experiments have been made, with a view to ascertain the utility of *common salt* as a manure, yet, from the difference which has been experienced in their results, no very decisive or satisfactory conclusion has hitherto been obtained on the subject.

Rape dust is another excellent manure, and has been used in several instances with the greatest advantage. The large proportion of oily and mucilaginous matter which it contains, might indeed induce a belief, *à priori*, that this would be the case.

Refuse leather, soap suds, woollen rags, &c. have each been used, to a certain extent, as manures in some counties; and with different degrees of success.

The *dung* of those animals which are fed upon the substances constituting in a great measure the subsistence of man, is esteemed more valuable than that procured from animals whose food is of a different description. The dung of swine, of horses fed upon corn, &c. is said to be more beneficial as a manure, than that of cows, sheep, or horses fed entirely upon grass or hay.

The generality of agricultural writers, in treating of manures, have given innumerable directions for the management of the several varieties, as if the farmer had a store-house, or repository, into which each could be deposited. We have spoken of them in such a way as may serve every useful purpose; and, without troubling the reader with instructions which cannot be carried into execution, we have restricted our details to matters that are practicable by every farmer. We have directed his attention to the management and application of dung, because this article may be considered as the magic wand which influences every rural operation. Instead of troubling him with speculative opinions on the principles of vegetation, and the pasture of plants, subjects of an abstruse nature, and on which the best informed can only form crude and uncertain notions, we have pointed out the manner in which the greatest quantity of dung may be collected, and have described the most suitable and profitable method of applying it to the land. We have treated of lime, and other stimulants, in the same manner; every kind of theory being avoided.

Many valuable essays on agriculture have appeared in the United States; and particularly the application of manures to land. Since the establishment of societies, and particularly of the Agricultural Society of Philadelphia, which does so much honour to our country, this subject has already undergone many improvements. In the memoirs of that society, several valuable essays on manure may be found; to one of which I would call the attention of the reader, namely, the experiments and observations of the honourable Richard Peters, on gypsum, or plaster of Paris.

On the Cultivation of Culmiferous Crops.—The varieties of grain ranked as culmiferous, are Wheat, Barley, Oats, and Rye. These varieties we are inclined to consider as bearing equally hard upon the soil; and we think it does not matter much which of them are taken, because all are robbers of the ground, and tend to exhaust it of its productive powers. No doubt some soils are more favourable for one sort of corn than for another; as, for instance, clays and loams are better adapted for wheat than sands and gravels; while, *vice versa*, the latter are better calculated for barley than the heavy soils. It is by fixing upon the most proper of each for the soil cultivated, that the judgment of the farmer is correctly ascertained. In other respects, such as the exhaustion of the ground, we view it as a matter of no importance which of them is preferred.

As wheat is the most valuable grain cultivated in this country, we shall treat of the several processes connected with its culture in a more particular manner than may afterwards be required, when other grains occupy our attention. We shall first speak of the soils best adapted to the growth of wheat; 2. Of the culture required for that grain; 3. Of the varieties of seed; 4. of the way in which it is sown; 5. Of pickling the seed, so that it may be preserved from being smutted or blacked; 6. Of the diseases to which wheat is liable in different stages; 7. Of harvest management; 8. Of thrashing the grain, and preparing it for market.

1. *On the Soils best adapted for the Growth of Wheat.*—Rich clays and heavy loams are naturally well calculated for

producing wheat; but any kind of clay and loamy soil, situated in a proper climate, may be artificially adapted to the growth of that grain, by enriching it with a sufficient quantity of manure. On soils of the first description, wheat may be cultivated almost every second year, provided due care is taken to keep the land clean, and in good condition. A summer fallow once in four, six, or eight years, according to seasons and circumstances, is, however, necessary; and manure should be applied on that fallow for the first crop of wheat.

Light soils, though they will, with the exception of soft sands, produce wheat of excellent quality, are not constitutionally disposed to the growth of that grain. Summer fallow on them may safely be dispensed with; because a crop of turnips, which admits every branch of the cleaning process to be more perfectly executed than even a naked or bare fallow does, may be profitably substituted. Wheat here comes in with propriety after turnips, though, in general cases, it must be sown in the spring months, unless the turnips are stored; in which case, it may be sown in November; or it may be sown after clover, for the fourth crop of the rotation; or in the sixth year, as a way-going crop, after drilled pease and beans, if the rotation is extended to that length. Neither is it possible to raise wheat so extensively upon light soils, even where they are of the richest quality, as is practicable upon clays; nor will a crop of equal bulk, upon the one, return so much produce in grain as may be got from the other. To enlarge upon this point would only serve to prove what few husbandmen will dispute, though, it may be added, that, on real sands, wheat ought not to be ventured, unless they are either completely clayed or marled, as it is only with the help of these auxiliaries that such a soil can gain stamina capable of producing wheat with any degree of success.

2. *On the Culture required for Wheat.*—On soils really calculated for wheat, though in different degrees, summer-fallow is the first and leading step to gain a good crop or crops of that grain. The first furrow should be given before winter, or so early as other operations upon the farm will admit; and every attention should be used to go as deep as possible; for it rarely happens that any of the succeeding furrows exceed the first one in that respect. The number of after-ploughings must be regulated by the condition of the ground and the state of the weather; but, in general, it may be observed, that ploughing in length and across, alternately, is the way by which the ground will be most completely cut, and the intention of fallowing accomplished. In a dry season, it is almost impracticable to reduce real clays, or to work them too small; and even in a wet one, supposing they are made surface smooth, they will, when ploughed up again, consolidate into clods or big lumps, after forty-eight hours drought, and become nearly as obdurate as ever. It is only on thin soils, which have a mixture of peat-earth, and are incumbent on a bottom impervious to water, that damage is at any time sustained from over harrowing.

Some people think it improper to dung rich clays or loams when fallowed, and choose rather to reserve that restorative till the succeeding season. Delaying the manuring process for a year is attended with many advantages; because good land, fully wrought, contains such a principle of action within itself, as often causes the first wheat crop to be lodged before it is filled; under which circumstance, the produce is diminished both in quantity and quality. This delay in manuring is, however, attended with disadvantages; because, when dung is kept back till the end of autumn or beginning of winter, to be laid on the stubbles, the weather is often so wet that it cannot be carted out without subjecting the land to injury from poaching, whilst the labour in laying it on is also increased. On thin clays, or even upon soils of the other description not in high condition, there can be no doubt but that the end of summer, and upon summer fallow, is the most proper time for manuring them, though it will be found that an improvident expenditure of dung, on such occasions, ought always to be steadily avoided.

3. *On the Varieties of Seed*—Wheat may be classed under two principal divisions, though each of these admits of several subdivisions. The first is composed of all the varieties of red wheat; but as such are now rarely sown, being at least 15 pounds per cent. inferior in value to those which are generally cultivated, it is unnecessary to say any thing about them. The second division comprehends the whole varieties of white under two distinct heads, namely, *thick, chaffed* and *thin chaffed.* The thick chaffed varieties were formerly in the greatest repute, generally yielding the whitest and finest flour, and, in dry seasons, not inferior in produce to the other; but since the disease called mildew, to which they are constitutionally predisposed, raged so extensively, they have gradually been going out of fashion. Under these circum-

stances, it seems unnecessary to notice them more particularly.

The thin chaffed wheats are a hardy class, and seldom mildewed, unless the weather be particularly inimical during the stages of blossoming, filling, and ripening, though some of them are rather better qualified to resist that destructive disorder than others. A nomenclature of thin chaffed wheats might be useful; but, at present, any thing of that nature is an impossible task; because, even with agriculturists, their names are altogether arbitrary. It has been often noticed, that this class of wheat preserves a green healthy aspect during the coldest weather, when other varieties assume a sickly and jaundiced hue. The resistance which it shows to the effects of inclement weather, perhaps proceeds from the strength of its roots, though the effect may be easier described than the cause accounted for.

4. *On Seed Work.*—Sowing in the broadcast way may be said to be the mode universally practised, for the trifling deviations from it can hardly be admitted as an exception. Upon well prepared lands, if the seed be distributed equally, it can scarcely be sown too thin; perhaps two bushels per acre are sufficient; for the heaviest crops at autumn are rarely those which show the most vigorous appearance through the winter months. Thin sowing in spring ought not to be practised, otherwise the crop will be late, and imperfectly ripened. No more harrowing should be given to fields that have been fallowed, than what is necessary to cover the seed, and level the surface sufficiently. Ground which is to lie in a broken down state through the winter, suffers severely when an excessive harrowing is given, especially if it is incumbent on a close bottom; though, as to the quantity necessary, none can give an opinion, except those who are personally present.

5. *On Pickling the Seed.*—This process is indispensably necessary on every soil; otherwise, smut to a greater or less extent, is apt to follow. Though almost all practical farmers are agreed as to the necessity of pickling, yet they are not so unanimous as to the *modus operandi* of the process, and the article which is best calculated to answer the intended purpose. Stale urine may be considered as the safest and surest pickle; and where it can be obtained in a sufficient quantity is commonly resorted to. The mode of using it does not, however, seem to be agreed upon; for, while one party contends that the grain ought to be steeped in the urine, another party considers it as sufficient to sprinkle the urine upon it. Some, again, are advocates for a pickle made of salt and water, sufficiently strong to buoy up an egg, in which the grain is to be thoroughly steeped. But whatever difference of opinion there may be as to the kind of pickle that ought to be used, and the mode of using it, all admit the utility of mixing the wetted seed with hot lime fresh slacked; and this, in one point of view, is absolutely necessary, so that the seed may be equally distributed. It may be remarked, that experience justifies the utility of all these modes, provided they are attentively carried into execution. There is some danger from the first; for, if the seed steeped in urine is not immediately sown, it will infallibly lose its vegetative power. The second, viz. sprinkling the urine on the seed, seems to be the safest, if performed by an attentive hand; whilst the last may do equally well, if such a quantity of salt be incorporated with the water, as to render it of sufficient strength. It may also be remarked, that this last mode is oftener accompanied with smut, owing no doubt to a deficiency of strength in the pickle; whereas a single head with smut is rarely discovered when urine has been used.

6. *Diseases of Wheat.*—Wheat is subject to more diseases than other grains, and in some seasons, especially in wet ones, heavier losses are sustained from those diseases, than are felt in the culture of any other culmiferous crop with which we are acquainted. Wheat may suffer from the attack of insects at the root; from blight, which primarily affects the leaf or straw, and ultimately deprives the grain of sufficient nourishment; from mildew on the ear, which operates thereon with the force of an apoplectic stroke; and from gum of different shades, which lodges on the chaff or cups in which the grain is deposited. Theorists often neglect these distinctions, or confound the different disorders to which this valuable grain is exposed; but the practical farmer, who sedulously examines his crop in every stage of its growth, will not readily fall into such errors.

It has, without inquiry, been taken for granted by some people, that blight, mildew, and rust, are the same disorder, though most agriculturists have hitherto reckoned them separate diseases, brought on at different periods, and occasioned by different causes. It may be laid down as a primary principle, that the proximate cause of every disease which attacks the stalk and ear of wheat plants may be found in the state of the weather at the time, conjoined with the circumstances of

soil, situation, and the seed that has been used. It is difficult to classify these diseases, or describe them in a distinct manner; because the sentiments, or rather the language of agriculturists on this subject is arbitrary and indistinct. Notwithstanding that they are, by the great body of farmers, attributed to atmospherical influence solely, yet much confusion arises in their nomenclature; for many people use the terms of *blight*, *mildew*, and *rust*, as synonymous, though, to us, they appear to be distinct diseases.

Blight, according to our ideas, originates from moist or foggy weather, and from hoar-frost, the effects of which, when expelled by a hot sun, are first discernible on the straw, and afterwards on the ear, in a greater or lesser degree, according to local circumstances.

Mildew, again, strictly speaking, may be ranked as a disease which affects the ear, and is brought on by causes somewhat similar to those which occasion blight, though at a more advanced period of the season. These different disorders are generally accompanied by insects; which animalculæ, by many people who take the effect for the cause, are considered, though without the least foundation, as the authors of the mischief that follows. Their appearance, however, may justly be attributed to the diseased state of the plant; for wherever putrefaction takes place, either in animal or vegetable substances, the presence of these insects will never be wanting.

Another disorder which affects wheat, and by several people denominated the real rust, is brought on by excessive heats, which occasion the plants to suffer from a privation of nourishment, and become sickly and feeble. In this atrophical state, a kind of dust gathers on the stalk and leaves, which increases with the disease, till the plant is in a great measure worn out and exhausted. The only remedy in this case, and it is one that cannot easily be administered by the hand of man, is a plentiful supply of moisture, by which, if it is received, before consumption is too far advanced, the crop is benefited in a degree proportional to the extent of nourishment received, and the stage at which the disease has arrived.

Some people have recommended the sowing of blighted and mildewed wheat, because it will vegetate; though certainly the recommendation, if carried into practice, would be attended with imminent danger to those who attempted it. That light or defective wheat will vegetate and produce a plant, we are not disposed to contradict; but that it will vegetate as briskly, or put out a stem of equal strength, and capable of withstanding the severe winter blasts, as those produced from sound seed, we must be excused for not believing. Let it only be considered, that a plant of young wheat, unless when very early sown, lives three or four months, in a great measure, upon the nourishment which it derives from the parent seed; and that such nourishment can, in no view of the subject, be so great, when the parent is lean and emaciated, as when sound, healthy, and vigorous. Let it also be remembered, that a plant produced from the best, and weightiest seed, must, in every case, under a parity of other circumstances, have a stronger constitution at the outset, which necessarily qualifies it to push on with greater energy when the season of growth arrives. Indeed, the economy of nature would be overturned, had any other result followed. A breeder of cattle or sheep would not act more foolishly, who trusted that a deformed diminutive bull or ram would produce him good stock, than the corn farmer does who uses unsound or imperfect seed.

But another reason operates with us against the use of mildewed wheat, which at least deserves consideration:—Is there not some risk that the disease may be conveyed from the parent to the crop, and that the produce may thereby be lessened? We do not go so far as to say, that this disease, like smut, begets its like, though there is a degree of risk in the use of mildewed seed, which no prudent farmer would choose to hazard, who could avoid it.

7. *On Harvest Management*.—It is advantageous to cut wheat before it is fully ripe; but in ascertaining the proper state, it is necessary to discriminate betwixt the ripeness of the straw and the ripeness of the grain; for, in some seasons, the straw dies upwards; under which circumstance, a field, to the eye, may appear to be completely fit for the sickle, when, in reality, the grain is imperfectly consolidated, and perhaps not much removed from a milky state. Though it is obvious, that, under such circumstances, no further benefit can be conveyed from the root, and that nourishment is withheld the moment that the roots die; yet it does not follow, that grain so circumstanced should be immediately cut: because, after that operation is performed, it is in a great measure necessarily deprived of every benefit from the sun and air, both of which have greater influence in bringing it to maturity, so long as it remains on foot, than when cut down, whether laid on the ground, or bound up

in sheaves. The state of the weather at the time also deserves notice; for, in moist, or even variable weather, every kind of grain, when cut prematurely, is more exposed to damage than when completely ripened. All these things will be studied by the skilful husbandman, who will also take into consideration the dangers which may follow, were he to permit his wheat crop to remain uncut till completely ripened. The danger from wind will not be lost sight of, even the quantity dropped in the field, and in the stack-yard, when wheat is over ripe, is an object of consideration. Taking all these things into view, it seems prudent to have wheat cut before it is fully ripe, as less damage will be sustained from acting in this way than by adopting a contrary practice.

If the weather be dry, and the straw clean, wheat may be carted to the stack-yard in a few days; indeed, if quite ripe, it may be stacked immediately from the sickle, especially when not meant for early thrashing. So long, however, as any moisture remains in the straw, the field will be found to be the best stack-yard; and where grass or weeds of any kind are mixed with the crop, patience must be exerted till they are decayed and dried, lest heating be occasioned; which, independent of the loss, is to the farmer a most disgraceful affair.

8. *On Thrashing Wheat.*—Before thrashing machines were introduced, the task of separating wheat from the straw was arduous and difficult. The expense was very considerable, whilst the severity of the labour almost exceeded the power of the strongest man, especially in unfavourable seasons, when the grain adhered pertinaciously to the ear, and could not, without difficulty, be completely loosened and removed. Every thing of this nature, however, may be prevented, now that thrashing machines are introduced, provided the feeder is careful, and proportions the quantity on the board to the strength of the impelling power. Wheat, in fact, is now the cleanest thrashed grain; because the length of the straw allows it to be properly beat out before it passes the machine, which sometimes is not the case with short oats and barley. If horses are used as the impelling power, thin feeding is necessary, otherwise the animals may be injured; but where wind or water is employed, the business of thrashing is executed speedily, completely, and economically.

On Barley.—Next to wheat, the most valuable grain is barley, especially on light and sharp soils.

It is a tender grain, and easily hurt in any of the stages of its growth, particularly at seed time; a heavy shower of rain will then almost ruin a crop on the best prepared land; and in all the after processes, greater pains and attention are required to ensure success, than in the case of other grains. The harvest process is difficult, and often attended with danger; even the thrashing of it is not easily executed with machines, because the awn, or tail, generally adheres to the grain, and renders separation from the straw a troublesome task. Barley, in fact, is raised at greater expense than wheat, and, generally speaking, is a more hazardous crop.

Barley may be divided into two sorts, early and late; to which may be added a bastard variety, called bear, or big, which affords similar nutriment, or substance, though of inferior quality. Early barley, under various names, was formerly sown upon lands that had been previously summer fallowed, or were in high condition; but this mode of culture being in a great measure renounced, the common sort, which admits of being sown either early or late, is now generally used. The most proper seed season is any time in April, though we have seen good crops produced, the seed of which was sown at a much later period. Bear, or big, may be sown still later than common barley; because it ripens with greater rapidity. But, as a general principle, where land is in order, early sowing, of every variety, is most desirable

Quantity of Seed.—The quantity sown is different in different cases, according to the quality of the soil, and other circumstances. Upon very rich lands, eight pecks per acre are sometimes sown; twelve is very common; and, upon poor land, more is sometimes given. Among the best farmers, it seems a disputed point, whether the practice of giving so small a quantity of seed to the best lands is advantageous. That there is a saving of grain, there can be no doubt; and that the bulk may be as great, as if more seed had been sown, there can be as little question. By good judges, it is thought preferable to sow a quantity of seed sufficient to ensure a full crop, without depending on its sending out offsets; indeed, where that is done, few offsets are produced, the crop grows and ripens equally, and the grain is uniformly good.

Harvesting.—More care is required in the harvesting of barley, than any of the other white crops, even in the best of seasons; and in bad years it is often found very difficult to save it. Owing to the brittleness of the straw, after it has reached a certain period, it must be cut down;

as, when it is suffered to stand longer, much loss is sustained by the breaking of the heads. On that account, it is cut at a time when the grain is soft, and the straw retains a great proportion of its natural juices, consequently requires a long time in the field, before either the grain is hardened, or the straw sufficiently dry. When put into the stack sooner, it is apt to heat, and much loss is frequently sustained. It is a custom with many farmers to have an opening in the middle of their barley stacks, from top to bottom. This opening is generally made by placing a large bundle of straw in the centre of the stack, when the building commences, and, in proportion as it rises, the straw is drawn upwards, leaving a hollow behind; which, if one or two openings are left in the side of the stack near the bottom, ensures so complete a circulation of air, as not only to prevent heating, but to preserve the grain from becoming musty.

On Oats.—Of this grain the varieties are more numerous than of any other of the culmiferous tribe. These varieties consist of what is called the common oat; the Angus oat, which we consider as an improved variety of the other; the Poland oat; the Friesland oat; the red oat; the dun oat; the Tartar, or Siberian oat; and the potatoe oat. The Poland and potatoe varieties are best adapted to rich soils; the red oat, for late climates; and the other varieties, for the generality of soils. The Tartar, or Siberian kind, though very hardy and prolific, is much out of use, being of a coarse substance, and unproductive of meal. The dun oat has never been much cultivated; and the use of Poland's and Friesland's is now much circumscribed, since potatoe oats were introduced, the latter being considered, by the most discerning agriculturists, as of superior value, in every respect, where the soil is rich and properly cultivated.

Preparation.—Oats are chiefly sown after grass; sometimes upon land not rich enough for wheat, that had been previously summer fallowed, or had carried turnips; often after barley, and rarely after wheat, unless cross cropping, from particular circumstances, becomes a necessary evil. One ploughing is generally given to the grass lands, usually in the month of January, so that the benefit of frost may be gained, and the land sufficiently mellowed for receiving the harrow. In some cases, a spring furrow is given, when oats succeed wheat or barley, especially when grass seeds are to accompany the crop. The best oats, both in quantity and quality, are always those which succeed grass; indeed, no kind of grain seems better qualified by nature, for foraging upon grass land, than oats; as a full crop is usually obtained in the first instance, and the land left in good order for succeeding ones.

Quantity of Seed.—From twelve to eighteen pecks of seed is generally allowed to the acre of ground, according to the richness of the soil, and the variety that is cultivated. Here it may be remarked, that land, sown with potatoe oats, requires much less seed, in point of measure, than when any of the other sorts are used; because potatoe oats till much better than Poland ones, and have not an awn, or tail, like the ordinary varieties. On that account, a measure contains many more seeds of them, than of any other kind. If land is equally well cultivated, we have little doubt, but that the like quantity of seed, given when barley is cultivated, may be safely trusted to when potatoe oats are to be raised.

Harvesting.—Oats are a hardy grain, and rarely get much damage when under the harvest process, except from high winds, or from shedding, when opened out after being thoroughly wetted. The early varieties are much more liable to these losses, than the late ones; because the grain parts more easily fall from the straw, an evil to which the best of grain is at all times subject. Early oats, however, may be cut a little quick, which, to a certain extent, lessens the danger to which they are exposed from high winds; and, if the sheaves be made small, the danger from shedding after rains is considerably lessened, because they are thus sooner ready for the stack. Under every management, however, a greater quantity of early oats will be lost during the harvest process, than of late ones; because the latter adhere firmly to the straw, and consequently do not drop so easily as the former.

On Rye.—Rye ought never to be sown upon wet soils, nor even upon sandy soils where the subsoil is of a retentive nature. Upon downs, links, and all soft lands, which have received manure, this grain thrives in perfection, and, if once covered in, will stand a drought afterwards, that would consume any of the culmiferous tribe. The several processes may be regarded as nearly the same with those recommended for wheat, with the single exception of pickling, which rye does not require. Rye may be sown either in winter or spring, though the winter-seeded fields are generally bulkiest and most productive. It may succeed either summer fallow, clover, or turnips; even after oats, good crops have been raised, and where

such crops are raised, the land will always be found in good condition.

On Corn.—Indian corn or maize; for the culture of which, prepare the ground by ploughing it in single lengths in the autumn, in the spring harrow it down as smooth as possible, then plough and harrow it again; afterward mark out the furrows at right angles, five or six feet apart, according to the strength of the soil. At the intersection of these furrows drop two or three seeds, four or five inches apart, cover them about three inches with manure, and afterwards with mould by the hoe. By this method the plants come soon up and flourish vigorously: when they are five or six inches high plough between them, taking the mould from the plants, throwing it up in a ridge, and with a hoe cut up the weeds and superfluous plants. The subsequent periods of ploughing are quite arbitrary: but an attentive farmer will readily discover when the plants require support, or when the weeds begin to filch their nourishment. The next ploughing the mould must be removed from the ridge to the plants, taking care to till the ground between them, and to destroy all the weeds. This is of more use than would at first be imagined, for it not only prevents the robbing of the plants, but admits the influence of the air and dews to penetrate to their roots.

The third ploughing the soil must again be removed from the plants, and the weeds destroyed: the fourth and last ploughing must be managed like the second by throwing up the mould to the stalks of corn.

Previous to ploughing, the seed should be soaked in water moderately warm over night: then add a small quantity of tar, which must be stirred till the grains appear to be uniformly coated with it. After the water has been drained off, add as much slacked lime, ashes, or gypsum, as will adhere to the grains, which will cause the grains to separate, so that they may be as conveniently planted as though they had never been tarred.

This preparation will preserve the tender plants from the ravages of the birds, squirrels, &c. which prove very destructive to the fields of corn in many parts of the United States. Corn that has been steeped in a strong infusion of Indian poke or tobacco, and scattered over the field before the plants are up, is also an excellent preventive.

At the second or third hoeing, the suckers should be bent down and buried under the soil; to break them wounds and materially injures the parent stock. Some think high hills are necessary to make the corn stand upright; but it is undoubtedly oftener broke when the hills are high, which is a greater evil than for it to lean, which would be the consequence if the hills were low; nor would this circumstance prevent their maturing to a tolerable degree of perfection. The farmer who wishes for a long crop should not annoy his corn with running beans or pumpkins; the former, by winding round the stalks and ear cramp them in their growth and often bind them by the weight. The latter rob the soil of much vegetable food, and by their shade shut out the influence of the sun from the roots of the corn. Neither should he, for the sake of the fodder, cut or top-stalk the plant, for by such a wound the corn is much more injured, than the difference in the quality of the fodder will compensate for. The time for corn planting depends on the climate and season: it, however, should be got in as early as possible after the season of frost, that it may be advanced in strength and constitution, to enable it the better to conflict with the drought which sometimes occurs.

When the period for harvesting has arrived, which will be readily known by the consistency of the kernel, cut the stalks close to the ground, remove the whole near the farm house, strip the husks from the ear, and after permitting both to dry, place the corn in cribs to be ready for thrashing, and stack the husks, &c. to be distributed to the cattle during the approaching winter.

The best method of preserving corn, and in fact every species of grain, is to move and air it frequently for the first six months; after that time it will require less labour, if kept in a dry place. When the corn has been preserved from all impurities for the space of two years, and has exhaled all its *pirus*, it may be kept for any length of time by lodging it in pits covered with plank, closely joined together: but the safer way is to cover the heap with quick-lime, which should be dissolved by sprinkling it over with a small quantity of water; this causes the grains to shoot to the depth of two or three fingers, and incloses the heap with an incrustation, through which neither air nor insects can penetrate. For a further account of the different species of grain, see the *Domestic Encyclopedia*, articles WHEAT, CORN, &c.

Of Beans and Pease.—As the plants of beans and pease are of a hardy constitution, these articles requiring little more than to be deposited in the earth to cause a generous reproduction; so also their cultivation is little more attended to in this

country than to obtain a garden supply, and as the attention they require is so generally understood, a particular account of their cultivation is thought unnecessary. Those of our readers, however, who are desirous of information on this head, are referred to M'Mahon's *System of Horticulture*, and Brewster's *Encyclopedia*, article AGRICULTURE.

Of Potatoes.—Considering potatoes as an article of human food, next to wheat of the greatest importance, in the eye of a political economist, it is proper to illustrate the culture of this esculent in the various stages, from preparing the ground, till the crop is digged up and ready for market.

Preparation of the ground.—To work the ground till it is completely reduced and free from root-weeds, may be considered as a desideratum in potatoe husbandry; though in many seasons these operations cannot be perfectly executed, without losing the proper time for planting, which never ought to be beyond the first of May, if circumstances do not absolutely interdict it. Three ploughings, with frequent harrowings and rollings, are necessary in both cases, before the land is in suitable condition. When this is accomplished, form the drills from two to three feet apart; cart out the manure, which ought not to be sparingly applied, plant the seed above the manure, reverse the drills for covering it and the seed, then harrow the drills in length, which completes the preparation and seed process.

They are sometimes planted with the hoe, in the same manner as corn, though somewhat nearer.

Quantity of Seed.—It is not advantageous to cut the seed into small slips; for the strength of the stem at the outset depends in direct proportion upon the vigour and power of the seed-plant. At all events, rather err in giving over large seed than in making it too small; because by the first error, no great loss can ever be sustained; whereas, by the other, a feeble and late crop may be the consequence. When the seed is properly cut, it requires from ten to twelve hundred weight of potatoes to plant an acre of ground, where the rows are at 27 inches distance; but this quantity depends greatly upon the size of the potatoes used; if they are large, a greater weight may be required, but the extra quantity will be abundantly repaid by the superiority of crop which large seed usually produces.

Of the kinds of Potatoe which can be most successfully cultivated.—The varieties of this excellent root are become so numerous, that it is impossible to treat of each, or even to give a list of their names or particular properties. It is almost certain, that a new variety may be propagated at any time, by mixing contrary sorts in the same drill; and if these are allowed to come to maturity, a kind of connection takes place betwixt the blossoms of each, which produces a new race or variety. In this way, the numerous varieties of the potatoe root have been procreated and introduced.

Cleaning of Potatoes.—After having detailed the method of cleaning corn so circumstantially, it appears unnecessary to enter at much length upon what is required for potatoes, because one and all of the green crops require somewhat similar management.

It may be remarked, that green crops of every kind are greatly benefited by frequent hoeings, and that their growth, in some measure, is regulated by the extent of labour bestowed on them. When treated in a slovenly manner, or left to fight with weeds, or even to encounter a firm soil, the plants are deprived of nourishment, and unable to procreate their kind in due abundance; on the contrary, when the soil is sufficiently stirred up, and kept free of weeds, nature will return a crop in direct proportion to the quality of the soil, and the quantity of manure bestowed upon it by the cultivator. Nature may be improved by art, but when her bounties are neglected, and not improved, she generally turns aside, and repays the contempt with interest.

Method of taking up the crop, and storing it for consumption.—Potatoes are generally digged up with a hoe, three-prong grape, or fork; but at other times, when the weather is dry, the plough is used, which is the most expeditious implement. After gathering the interval, the furrow taken by the plough is broken and separated; in which way the crop may be more completely gathered than when taken up by the grape. The potatoes are then stored up for winter and spring use; and as it is of importance to keep them as long through summer as possible, every endeavour ought to be made to preserve them from frost, and from sprouting in the spring months. The former is accomplished by covering them well with straw when lodged in a house, and by a thick coat of earth, when deposited in a pit; and the latter, by picking them carefully, at different times, when they begin to sprout, drying them sufficiently by exposure to the sun, or by a gentle toast on a kiln. Careful people often preserve potatoes in perfection till the succeeding crop is fit for use; though it rarely happens that

they possess their original qualities after summer commences.

Of turnips.—The benefits derived from turnip husbandry, are of great magnitude; light soils are cultivated with profit and facility; abundance of food is provided for man and beast; the earth is turned to the uses for which it is physically calculated; and, by being suitably cleaned with this preparatory crop, a bed is provided for grass seeds, wherein they flourish and prosper with greater vigour than after any other preparation.

Preparation.—The first and second ploughings are given usually in contrary directions. It is then repeatedly harrowed, often rolled between the harrowings, and every particle of root weeds carefully picked off with the hand; a third ploughing is then bestowed, and the other operations are repeated. In this stage, if the ground has not been very foul, the seed process generally commences; but often a fourth ploughing, sometimes a fifth, is necessary, before the ground is sufficiently cleaned.

Turnip land cannot be made too rich, for, in fact, the weight of the crop depends in a great measure upon its condition in this respect.

The next part of the process is the sowing of the seed. From two to three pounds of seed are sown upon the acre, though the smallest of these quantities will give many more plants, in ordinary seasons, than are necessary; but, as the seed is not an expensive article, the greater part of farmers incline to sow thick, which both provides against the danger of part of the seed perishing, and gives the young plants an advantage at the outset.

Turnips are sown from the beginning of June to the middle of August; but the last of July is, by judicious farmers, accounted the most proper time. As a general rule, it may be laid down, that the earliest sowing should be on the latest soils; plants on such soils are often long before they make any great progress; and in the end, may be far behind those, in other situations, which were much later sown. The turnip plant, indeed, does not thrive rapidly till its roots reach the dung.

The hand-hoeing then commences, by which the turnips are all singled out, at a distance of eight inches, which is an operation of great importance, for an error committed in this process can hardly be afterwards rectified. Care must afterwards be taken to stir the soil often, destroy the superfluous plants, and keep the weeds down.

On Crops to be used in Manufactures.—Three other crops remain to be treated of; namely, hemp, flax, and hops. None of these, however, can be viewed as improving crops; on the contrary, they may be characterized as robbers, that exhaust the soil, and return little, or rather no manure for restoring it to fertility. They are, however, all necessary articles, and in the present state of public affairs, the culture of the two first, viz. hemp and flax, may be considered as materially connected with national prosperity.

On Hemp.—This is a plant of the herbaceous fibrous-rooted kind, which has a thick strong stem, that rises to a considerable height, and affords a rind or covering of a firm strong texture, that is valuable for the purpose of being manufactured into cloth, cordage, &c.

The soils most suited to the culture of this plant, are those of the deep, black, putrid, vegetable kind, that are low, and rather inclined to moisture, and those of the deep, mellow, loamy, or sandy descriptions. The quantity of produce is generally much greater on the former than on the latter; but it is said to be greatly inferior in quality. It may, however, be grown with success on lands of a less rich and fertile kind, by proper care and attention in their culture and preparation.

In order to render the grounds proper for the reception of the crop, they should be reduced into a fine mellow state of mould, and be perfectly cleared from weeds, by repeated ploughing. When it succeeds grain crops, the work is mostly accomplished by three ploughings, and as many harrowings; the first being given immediately after the preceding crop is removed, the second early in the spring, and the last, or seed earth, just before the seed is to be put in. In the last ploughing, well rotted manure, in the proportion of fifteen or twenty, or good compost, in the quantity of twenty-five or thirty cart loads per acre, should be turned into the land; as without this it is seldom that good crops can be produced. The surface of the ground being left perfectly flat, and as free from furrows as possible; as by these means the moisture is more effectually retained, and the growth of the plants more fully promoted.

Seed, and Method of Sowing.—It is of much importance in the cultivation of hemp crops, that the seed be new, and of a good quality, which may in some measure be known by its feeling heavy in the hands, and being of a bright shining colour.

The proportion of seed, that is most commonly employed, is from two to three bushels, according to the quality of the land; but, as the crops are greatly injured by the plants standing too closely togeth-

er, two bushels or two bushels and a half, may be a more advantageous quantity.

As the hemp plant is extremely tender in its early growth, care should be taken not to put the seed into the ground at so early a period, as that it may be liable to be injured by the effects of frost; nor to protract the sowing to so late a season, as that the quality of the produce may be affected. The best season, on the drier sorts of land, is, probably, as soon as possible after the frosts are over in April. But, when the ground is more inclined to moisture, it may be a better practice to delay the sowing to a later period, choosing, if possible, a time when the land is neither too dry nor too moist for performing the business. Sowing as early as possible is, however, in general, to be preferred; as, where this is the case, by the crops becoming more strong and vigorous in the early part of their growth, the hemp is found to withstand the various operations that are afterwards to be performed upon it in a better manner.

The most general method of putting crops of this sort into the soil is the broadcast, the seed being dispersed over the surface of the land in as even a manner as possible, and afterwards covered in by means of a very light harrowing. Care must constantly be taken to keep the birds from it for some time afterwards.

This sort of crop is frequently cultivated on the same piece of ground for a great number of years, without any other kind intervening; but, in such cases, manure must be applied, with almost every crop, in pretty large proportions, to prevent the exhaustion that must otherwise take place. It may be sown after most sorts of grain crops, especially where the land possesses sufficient fertility, and is in a proper state of tillage.

After Culture.—As hemp, from its tall growth and thick foliage, soon covers the surface of the land, and prevents the rising of weeds, little attention is necessary after the seed has been put into the ground.

In the culture of this plant, it is particularly necessary, that the same piece of land contains both *male* and *female*, or what is sometimes denominated *simple* hemp. The latter kind contains the seed.

When the crop is ripe, which is known by its becoming of a whitish yellow colour, and a few of the leaves beginning to drop from the stems, which happens commonly about thirteen or fourteen weeks from the period of its being sown, according as the season may be dry or wet, the first sort being mostly ripe some weeks before the latter;—the next operation is that of taking it from the ground, which is effected by pulling it up by the roots, in small parcels at a time, by the hand, taking care to shake off the mould well from them before the handfuls are laid down. In some districts, the whole crop is pulled together, without any distinction being made between the different kinds of hemp; while, in others, it is the practice to separate and pull them at different times, according to their ripeness. The latter is obviously the better practice; as by pulling a large proportion of the crop before it is in a proper state of maturity, the quantity of produce must not only be considerably lessened, but its quality greatly injured, by being rendered less durable. After being thus pulled, it is tied up in small parcels, or what are sometimes provincially termed *baits*.

Where crops of this kind are intended for seeding, they should be suffered to stand till the seed becomes in a perfect state of maturity, which is easily known by the appearance of it on inspection. The stems are then pulled and bound up, as in the other case, the bundles being set up in the same manner as grain, until the seed becomes so dry and firm as to shed freely. It is then either immediately thrashed out upon large cloths for the purpose in the field, or taken home to have the operation afterwards performed.

The after-management of hemp crops varies greatly in different places, where their culture is encouraged. In some, it is the practice only to, what is called, *dew-ripen*, or *ret*, the produce, while in others the general custom is to *water-ret* it.

In the former method, the hemp, immediately after being pulled, is carefully spread out in a very even, regular, and thin manner, on a piece of level old pasture, on which it is to remain for five, six, or more weeks, according to circumstances, being occasionally turned during the time. When the weather is showery, this is mostly done three times in the week; but in other cases twice is commonly sufficient. When the rind or hempy substance becomes easily separable from the woody part, or stem, it is taken up and tied into bundles, either to be stacked up on the spot, or carried home and placed in some convenient situation, where it may remain until it can be manufactured. In this process, which is termed *grassing*, great attention is requisite to prevent the texture of the hemp from being injured by its remaining too long on the grass.

But the latter practice is much better, and more expeditious as well as more general. In this, the hemp, as soon as pull-

ed, is tied up in small bundles, frequently at both ends. It is then conveyed to pits, or ponds of stagnant water, about six or eight feet in depth, such as have a clayey soil being in general preferred, and deposited in *beds*, according to their size and depth; the small bundles being laid both in a straight direction and crosswise of each other, so as to bind perfectly together; the whole being loaded with timber, or other materials, so as to keep the beds of hemp just below the surface of the water: the quantity of an acre, or three small waggon-loads, being in some instances piled in one bed. But as the action of the atmospheric air is essentially necessary to produce that degree of putrefaction, which is requisite for destroying the small fibres and vegetable gluten, by which the bark or hempy substance adheres to the *bun*, or stem, it may be more advantageous to build them in much smaller beds; as by such means the business may not only be more expeditiously accomplished, but the danger of rotting the hemp too much, prevented. On the same principle, the depth of the ponds should not exceed the dimensions given above. It is not usual to water more than four or five times in the same pit, till it has been filled with fresh water. Where the ponds are not sufficiently large to contain the whole of the produce at once, it is the practice to pull the hemp only as it can be admitted into them, it being thought disadvantageous to leave the hemp on the ground, after being pulled. It is left in these pits, four, five, or six days, or even more, according to the warmth of the season, and the judgment of the operator, on his examining whether the hempy material readily separates from the reed or stem; and then taken up and conveyed to a pasture field, which is clean and even, the bundles being loosed, and spread out thinly stem by stem, turning it every second or third day, especially in damp weather, to prevent its being injured by worms, or other insects It should remain in this situation for two, three, four, or more weeks, according to circumstances, and be then collected together when in a perfectly dry state, tied up into large bundles, and placed in some secure building until an opportunity is afforded for breaking it in order to separate the hemp. By this means, the process of *grassing* is not only shortened, but the more expensive ones of breaking, scutching, and bleaching the yarn, rendered less violent and troublesome. Besides, the hemp managed in this way, sells much dearer than when the former method is adopted. After the hemp has been removed from the field, and the business of *grassing* properly performed, it is in a state to be broken and swingled, operations that are mostly performed by common labourers, by means of machinery for the purpose, the produce being tied up in stones. The refuse, collected in the latter processes, is denominated *sheaves*, and is, in some districts, employed for the purposes of fuel, being sold at two pence the stone. After having undergone these different operations, it is ready for the purposes of the manufacturer.

On Flax.—Flax is not a severe crop on the soil, when pulled green, as it ought to be, if an article of good quality is wished for; though, when allowed to stand for seed, it is as severe a scourge as can be inflicted. The soils most suitable for flax, besides the alluvial kind are deep and friable loams, and such as contain a large proportion of vegetable matter in their composition. Strong clays do not answer well, nor soils of a gravelly or dry sandy nature. But whatever be the kind of soil, it ought neither to be in too poor nor in too rich a condition; because, in the latter case, the flax is apt to grow too luxuriant, and to produce a coarse sort; and, in the former case, the plant, from growing weakly, affords only a small produce.

Preparation.—When grass land is intended for flax, it ought to be broke up as early in the season as possible, so that the soil may be duly mellowed by the winter frosts, and in good order for being reduced by the harrows, when the seed process is attempted. If flax is to succeed a corn crop, the like care is required to procure the aid of frost, without which the surface cannot be rendered fine enough for receiving the seed. Less frost, however, will do in the last, than in the first case; therefore the grass land ought always to be earliest ploughed. At seed time, harrow the land well before the seed is distributed, then cover the seed to a sufficient depth, by giving a double to the harrows. Water-furrow the land, and remove any stones and roots that may remain on the surface; which finishes the seed process.

Quantity of Seed.—When a crop of seed is intended to be taken, thin sowing is preferable, in order that the plants may have room to fork or spread out their leaves, and to obtain air in the blossoming and filling seasons. But it is a mistake to sow thin, when flax is intended to be taken; for the crop then becomes coarse, and often unproductive. From eight to ten pecks per acre is a proper quantity in the last case; but when seed is the object, six pecks will do very well.

Time of Pulling.—Different opinions are held respecting the period when flax can be most profitably pulled; but, generally speaking, it is the safest course to take it a little early, any thing wanting in quantity being, in this way, made up by superiority of quality; besides, when pulled in a green state, flax is not a scourge, though this objection has been urged a hundred times against its culture. When suffered to ripen its seed sufficiently, there is no question but that flax is a severe crop, though not much more so than rye-grass, when allowed to stand till the seed is perfectly ripened. But as there is no necessity for allowing any great breadth of flax to remain for seed, the benefits to be derived from this crop are numerous, while the evils attending it are only partial; and, were sufficient care bestowed, even these evils might be done away almost altogether. Were flax for seed only sown on particular soils, for example, on new broken up moors, no detriment would follow; because these soils are fresh, and, in the first instance, will produce excellent seed, even of superior quality to what can be raised on lands of three times more value, when applied to corn culture.

Method of Watering.—When flax is pulled it ought to be immediately put into the water, so that it may part with the rind or shaw, and be fit for the manufacturer. Standing pools, for many reasons, are most proper for the purpose, occasioning the flax to have a better colour, to be sooner ready for the grass, and even to be of superior quality in every respect. When put into the water, it is tied up in *beets*, or small sheaves; the smaller the better, because it is then most equally watered. These sheaves ought to be built in the pool in a reclining upright posture, so that the weight placed above may keep the whole firm down. In warm weather, ten days of the watering process is sufficient; but it is proper to examine the pools regularly after the seventh day, lest the flax should putrefy or rot, which sometimes happens in very warm weather. Twelve days will answer in any sort of weather; though it may be remarked, that it is better to give rather too little of the water, than too much, as any deficiency may be easily made up by suffering it to lie longer on the grass, whereas an excess of water admits of no remedy. After lying on the grass for a due time, till any defect of the watering process is rectified, flax is taken up, tied when dry in large sheaves, and carried to the mill to be switched and prepared for the heckle. Switching may also be performed by hand-labour; though in this case it is rarely so perfectly accomplished as when machinery is employed.

On Hops.—Hops are a necessary article in brewing, but not advantageous in an agricultural point of view; because much manure is abstracted by them, while little or none is returned. They are an uncertain article of growth, often yielding large profits to the cultivator, and as often making an imperfect return, barely sufficient to defray the expenses of labour. In fact, hops are exposed to many more diseases than any other plant with which we are acquainted.

When a piece of land is intended to be planted, the first thing is to plough the land as deep as possible, early in October, and to harrow it level: it is then meted each way with a four rod chain, placing pieces of reed or stick at every tenth link, to mark the place of the hills, which makes 1000 per acre. This is the general method; but some few grounds are planted 800, and some 1200 per acre; some are planted wider one way than the other, in order to admit ploughing between the hills, instead of digging. But this practice, although it has been tried many years, does not seem to increase, on account of the difficulty of digging along the rows, where the plough cannot go; that part, being much trodden with the horses in ploughing, digs so much the worse, that an extra expense is incurred, which in some measure defeats the economy of the plan. When the hills are marked out, small holes are dug, which are filled with fine mould, and the nursery-plants placed in them.

Some put three plants, others two, and some only one good plant to each hole. If the land is planted with cuttings, instead of nursery-plants, the holes are dug in the spring, as soon as cutting time commences. Some fine mould is provided to fill up the holes, in which are placed four or five cuttings, each about three or four inches in length. They are covered about an inch deep with fine mould, and pressed down close with the hand. When the land is planted with cuttings, no sticks are required; but, if nursery plants are used, they require sticks, or small poles, six or seven feet high the first year. In both cases, the land is kept clean, during the summer, by horse and hand hoeing; the next winter dug with a spade; and early in the spring the old binds are cut off smooth, about an inch below the surface; a little fine mould is then drawn over the crown of the hills. As soon as the young shoots appear, so that the hills may be seen, they are stuck with small poles, from seven to ten feet long, in pro-

portion to the length it is expected the bind will run. As soon as the binds get about two feet in length, women are employed to tie them to the poles. The land is kept clean during the summer, by horse and hand hoeing, as before mentioned. The proper time for gathering them is known by the hop rubbing freely to pieces, and the seed beginning to turn brown. They are picked in baskets, and carried to the oast or kiln in bags, at noon and evening, for drying. Great care and skill are necessary in this branch of the business; the smallest neglect or ignorance in the management of the fires, will spoil the hops, and occasion great loss to the planter. When dried, and sufficiently cool to get a little tough, so as not to crumble to powder, they are put into bags, or pockets, the former containing two hundred weight and a half, and the latter, an hundred and a quarter: they are then trodden very close, and weighed for sale.

The second year after planting, full-sized poles, from 15 to 20 feet in length, according to the strength of the land, are placed to the hills instead of the seconds, which are removed to younger grounds. Here great care is necessary not to over-pole, for by that means young grounds are often much weakened; and it is equally so not to over-dung them, as that will make them mouldy. Fifty cart-loads of well rotted farm-yard dung and mould, once in three years, are generally esteemed sufficient for an acre of land.

Productions.—There can be no certain report made of the produce of the hop plantations; because, in some years, the growth is less than two hundred weight per acre, and in others it is fourteen or fifteen; the average may be seven or eight.

On Grasses for Cutting.—We are unacquainted with any variety of grass, that will yield a greater return to the farmer, when cut by the sithe, than broad or red clover mixed with a small quantity of timothy or rye-grass. The first mentioned may be regarded in most cases, as the parent which produces the crop, and the other only in the light of an assistant, or nurse, which serves to train up the crop to maturity, and to protect it from rude blasts and inclement storms. Fine soils alone are calculated to produce an heavy crop of grass, when clover is only used as the seed plant; but when a small quantity of rye-grass is sown along with the clover, it is wonderful what weight of crop may be obtained, even from inferior soils, when the seeds are sown at a proper season, on land in good order and condition. Some people make a greater mixture, and add a portion of white and yellow clover; but the addition is unnecessary, when a cutting crop only is meant to be taken; and we are convinced, that grass cut in one year ought to be ploughed in the next, otherwise a crop of inferior value will certainly be obtained. Laying this down therefore as a fixed rule, we consider sixteen pounds weight of red or broad clover, and two pecks of rye-grass seed, as a full allowance for an acre of ground. The seeds, to ensure a good crop of grass, ought always to be sown with a fallow crop; and, if with winter wheat, great care ought to be used to cover them properly, even though the welfare of the wheat should be hazarded by the harrowing process; if with spring wheat or barley, the grass seeds should be sown at the same time with these crops, none of which ought to be thickly seeded, so that the grasses may not be smothered or destroyed. Unless in very favourable seasons, and when the grass has grown to a great length at harvest, neither sheep nor cattle ought to be allowed to set a foot upon the stubbles; and next spring the ground should be carefully stoned, and afterwards rolled, so that the sithe may run smoothly upon the surface, and cut the crop as close as possible. The closer the first crop is cut, so much faster will the second one rush up, and so much thicker will the roots set out fresh stems, and thus produce a weighty after-crop. To cut the aftercrop with the sithe is also the most profitable way of using it; because a great quantity of food is thereby provided for live-stock, and a large increase made to the dung-hill.

On the Method of consuming cut Grass.—Clover and rye-grass, sown for a cutting crop, may be used in various ways: 1. As green food for the working stock. 2. For fattening the cattle, either put up in the stable, or kept in a court or farm-yard. 3. For hay. On each of these points we shall say a few words.

1. As green food for the working stock, clover and rye-grass may be used with great advantage, when in a succulent state; and when cut fresh, and furnished regularly, the animals will thrive equally well as if allowed to roam at large, while at least one-half less ground is required to support them in the former case than in the latter. Besides, horses kept in this way are always at hand, and ready for service. They are not injured, as in the field, by galloping about and kicking at each other; nor is their dung lost, as it is in a great measure when the field is pastured; but it is preserved in a moist

heap, the straw used for litter being saturated with the water, which, when on this food, they make in great quantities.

2. The next way of using clover and rye-grass cut by the sithe, is to feed cattle upon the grass by tying them up in a shade, or allowing them to run at large in a farm-yard. This is a practice of more recent date than that of feeding horses, though, by analogy, it may be inferred, that if this mode of feeding answers in the one case, it will do equally well in the other.

3. To convert clover and rye-grass into hay, or dry fodder, for winter consumption, is another way in which these grasses may be profitably used. It is well known, that, in common seasons, the process of cutting clover and rye-grass, and making them into excellent hay, is a very simple matter, and that with no other grasses can the hay process be so easily or speedily executed. To cut the plants a little quick, is obviously the best method of procuring good hay, and likewise of the most advantage to the ground; because the plants, not having perfected their seeds, extract from the ground much less of its strength or substance than would undoubtedly be drawn out, were they suffered to stand till they arrived at maturity. In fact, improvement from these varieties of grass is regulated entirely by the time of their cutting; and as it is early or late in the season when the cutting process is performed, so will the advantage to be derived from these grasses be ascertained. We here speak of the soil, not of the weight of the crop which may be reaped from it; though, when the first crop is late, or stands long uncut, the second is rarely of much value.

Grass, when cut for hay, ought to be quickly raked, in order that its powers may neither be exhausted by the sun, nor dissipated by the air. In the first stage small cocks are preferable; and on after days, these may be gathered into larger ones, or hand-ricks, by which method the hay is equally made, and properly sweated. After standing two or three days in these ricks, according to the nature of the weather, hay may be carted home, and built in stacks of sufficient size for standing through the winter months, or stored in farm houses. In ordinary weather, the processes of preparing hay and bringing it into good condition are easily executed, though, in bad weather, few branches of rural economy are attended with more vexation or performed with more difficulty. If this is the case with clover and rye-grass, the hazard and trouble are ten times greater when natural or meadow grasses are made into hay. In a wet season, these are rarely preserved in healthy condition; and in the very best, much more attention and work are required, than when artificial grasses are to be harvested.

Of Grass, when consumed by Live Stock.—Pasturage is the ancient and common method of consuming grass; and as many soils do not yield crops which can be consumed in any other way, it obviously must continue to be followed as the best way in which live stock can in general cases be fed or supported.

The grasses most fit for the sithe are not best calculated to make a good pasturage; nor ought seeds in the first mentioned instance to be sown so thick as is necessary when the grazing system is to be adopted. We have already said, that red clover and rye grass are the proper seeds for a crop, either to be used in soiling, or to be manufactured into hay; but when pasture is intended, white clover should be liberally used. A pasture field can scarcely be too thickly planted at the outset; because, being constantly eaten down by the cattle, the thickness of bottom is not detrimental, nay rather advantageous to its after growth. It is of importance, however, not to put beasts too early in the season upon new grass, and particularly to keep them off when the weather is wet. After the surface is consolidated, less risk of damage is encountered, though at all times pasturing by heavy cattle is attended with evil consequences during wet weather.

We are friends to alternate husbandry, and therefore hostile to every scheme calculated to keep land in grass constantly, or for any period comparatively long. There are many soils, however, which require to be longer grazed, not on account of the profit obtained by allowing them to remain in that state, but entirely because they will not pay for ploughing, unless freshened and invigorated by grass.

Upon thin soils of every description, sheep are a safer stock than black cattle, because the former will thrive where the latter will starve. An annual stock may also be considered as preferable to a breeding or standing one in all low country districts; and perhaps rearing of lambs for the butcher, and feeding their dams afterwards, is the most profitable way of keeping sheep.

On Draining.—Few improvements are attended with more salutary effects, than those accomplished by the removal of superfluous moisture from arable land; because, when such moisture is suffered to remain, ploughing can only be imperfectly performed, whilst the benefit of manure is in a great measure lost. To carry off

superfluous water is, therefore, an important object in the sight of every good farmer, meriting at all times his most assiduous attention.

Wherever a burst of water appears in any particular spot, the sure and certain way of getting quit of such an evil is to dig hollow drains, to such a depth below the surface as is required by the fall or level that can be gained, and by the quantity of water expected to proceed from the burst or spring. Having ascertained the extent of water to be carried off, taken the necessary levels, and cleared a mouth, or leading passage for the water, begin the drain at the extremity next to that leader, and go on with the work till the top of the spring is touched, which probably will accomplish the intended object. But if it should not be completely accomplished, run off from the main drain with such a number of branches, as may be required to intercept the water, and in this way, disappointment will hardly be experienced. Drains, to be substantially useful, should seldom be less than three feet in depth, twenty or twenty-four inches thereof to be close packed with stones or wood, according to circumstances. The former are the best materials, but in many places are not to be got in sufficient quantities; recourse therefore must often be made to the latter, though not so effectual or durable.

It is of vast importance to fill up drains as fast as they are dug out; because, if left open for any length of time, the earth is not only apt to fall in, but the sides get into a broken irregular state, which cannot afterwards be completely rectified. It also deserves attention, that a proper covering of straw or sod should be put upon the top of the materials, to keep the surface earth from mixing with them. Many farmers, nevertheless, drain much less in depth, and leave them entirely open.

The pit method of draining is a very effectual one, if executed with judgment. When it is sufficiently ascertained where the bed of water is deposited, which can easily be done by boring with an auger, sink a pit into the place, of a size which will allow a man freely to work within its bounds. Dig this pit of such a depth as to reach the bed of the water meant to be carried off; and when this depth is attained, which is easily discerned by the rising of the water, fill up the pit with big land stones, and carry off the water by a stout drain to some adjoining ditch or mouth, whence it may proceed to the nearest river. Indeed, if the proper spot is pitched upon for putting down the pit, the object must be attained; because the water being there stopped or impeded by a close substratum, is immediately set at liberty, when that substratum is pierced and cut through.

What is called the sod or pipe drain consists of a trench dug to a proper depth; after which a last spadeful is taken out in such a way as to leave a narrow channel, which can be covered by a sod or turf dug in grass land, and laid over it, the grass side downwards. Such drains are said to continue hollow, and to discharge well for a great number of years.

Another sod drain is thus made: When the line of drain is marked out, a sod is cut in the form of a wedge, the grass side being the narrowest, and the sods being from twelve to eighteen inches in length. The drain is then cut to the depth required, but it is contracted to a very narrow bottom. The sods are then set in with the grass side downwards, and pressed as far as they will go. As the figure of the drain does not suffer them to go to the bottom, a cavity is left which serves as a water course; and the space above is filled with the earth thrown out.

Another invention for draining land is described in the Agricultural Report of the County of Essex. It consists of a draining wheel of cast iron, that weighs about four cwt. It is four feet in diameter, the cutting edge or extremity of the circumference of the wheel is half an inch thick, and it increases in thickness towards the centre. At fifteen inches deep it will cut a drain half an inch wide at the bottom, and four inches wide at the top. The wheel is so placed in a frame, that it may be loaded at pleasure, and made to operate to a greater or less depth, according to the resistance made by the ground. It is used in winter when the soil is soft; and the wheel tracks are either immediately filled with straw ropes, and lightly covered over with earth, or they are left to crack wider and deeper till the ensuing summer; after which the fissures are filled with ropes of straw or of twisted twigs, and lightly covered over with the most porous earth that is at hand. Thus, upon grass lands, hollow drains, which answer extremely well, are formed at a trifling expense. It is said that twelve acres may be fully gone over with this draining wheel in one day, so as to make cuts at all necesssary distances.

On pastures a still simpler mode of removing surface water is practised in some places. Wherever the water is apt to stagnate, a deep furrow is turned up with a stout plough. After this, a man with a

spade pares off the loose soil from the inverted sod, and scatters it over the field, or casts it into hollow places. The sod thus pared, and brought to the thickness of about three inches, is restored to its original situation, with the grassy side uppermost, as if no furrow had been made. A pipe or opening is thus formed beneath it two or three inches deep in the bottom of the furrow, which is sufficient to discharge a considerable quantity of surface water, which readily sinks into it. These furrows, indeed, are easily choked up by any pressure, or by the growth of the roots of the grass; but they are also easily restored, and no surface is lost by means of them.

Though many of the above methods of draining are confessedly of a superficial nature, and only calculated to serve for a short period, yet a proof is furnished from them, that agriculturists in every quarter consider drainage as a most useful and necessary measure. Perhaps an over abundance of water is no less pernicious to many plants than the total want of it. At all events, when water stagnates upon the soil, the roots of plants will be rotted and destroyed. Even a temporary stagnation renders land unproductive; and the merits of every farmer may be completely ascertained, by the degree of attention employed to prevent such an evil. See Draining.

On Irrigation, or the method of improving Land by flooding it with Water.—From this a benefit has been derived sufficiently extensive, not only to defray the expenses incurred, but to afford a handsome return to the occupiers.

"The quality of the water most suitable for this purpose," says Dr. Singers, "may be ascertained by experiment. Let a small portion of land be floated with it for a month, about the latter end of harvest; and afterwards for a week or two, about the end of spring. The effects of this easy experiment will appear on the grass; either in respect of quantity, or quality, or both: and the warmth of the water may be sufficiently discovered, by its power of resisting early frosts, a matter of importance in irrigation.

The appearance of the water is not sufficient to determine its qualities. Thick muddy rivers, enriched in their passage through towns, and fertile soils, are not so frequently to be met with, as the friends of irrigation would wish. When these can be obtained, the operator may depend on their efficacy But clear alpine streams differ essentially in their qualities; and these are safest and most certainly ascertained, by observing the effect of the water and the periods of its freezing, as recommended above. With regard to those waters which are known to flow through beds of marl, there is reason to believe that much advantage may be obtained from the use of them, in a sweet and rich verdure, valuable for pasturage. Warm rivulets, containing great quantities of spring water, and resisting early frosts, may be expected to encourage an early pasturage, and probably also tolerable crops of hay. But mossy waters, darkened by the tincture of peat bogs, are very unpromising for the purposes of irrigation; though it is proper to give them a trial; and if mixed with marl waters, or conducted upon soils abounding with calcareous matters, they may be productive of benefit.

It is of importance, in many dry pastures, to water lands covered with moss, or with broom, heath, or other plants of less value to the farmer, for the purpose of extirpating these plants, and encouraging palatable grasses. On farms, which have no tendency to produce the rot, this practice may prove useful; but when there is any degree of risk from this distemper, the farmer will be cautious; he will suffer no summer watering; and he will allow no water to stagnate any where.

When lime and marl are very expensive, or difficult to be obtained, and water is at command, farmers sometimes water dry slopes, with a view to enrich them for crops of grain. This practice is ancient, and has often succeeded. But, it is admitted, that water enriches the soil for grass better than for corn.—The grain is often late and husky.

A flat meadow can only be watered in ridges, and requires a man of skill to lay it out in proper form, and the work is accomplished at a considerable expense.

A gentle declivity, which can be watered in catch-work, is an inviting subject. It perhaps produces little in the state of nature, but it may become productive by the application of water.

The quality of the soil is of little importance, when the water deposits a great deal of enriching sediment; for by means of that substance, any soil is rendered productive. Loam appears always to repay the irrigator with the heaviest and best crops; mossy soils answer very well; clay does not produce so abundantly; and gravel is generally poor and unproductive, in comparison,—at least for some years, and unless fully watered, or the water good.

It will readily occur to the reader, that streams of equal quality may differ materially in respect of the facility and safety

with which they can be managed, and conducted to the grounds which are intended to be floated: that whatever stream is fixed on for this purpose, the operator should determine, by means of a level, what lands are capable of being watered from it: that it is always convenient, and generally necessary, to enclose the meadows with proper fences, wears, or dams: and that a man of prudence will have an eye to the quantity of water, the demands of his farm, the chance of markets for any surplus he may have to spare, and the prospect of obtaining sufficient assistance in making his crops of hay, with ease and expedition. All these matters will have their due weight, in determining the grounds where a meadow shall be formed, and in fixing on the extent of it. The very common error, of laying out a greater quantity of meadow, than can be fully and properly floated, should by all means be avoided; as it leads to great expenses, and brings the practice of irrigation into discredit.

"It ought to be observed, that in catchwork, the surface of the meadow is seldom very much broken. Rough parts may be pared off, and some trivial work done in rafter levelling, which leaves a part of the sward. If any seeds are wanted, the proper kinds may be understood, by attending to what follows respecting flat meadows.

These are formed into ridges by the spade or plough, and are therefore almost totally destitute of grass, when newly laid down. To sow any seeds that are not perennial, or that would not agree with the soil and water, would prove a serious loss.

"If any trial has been made of the water, and it has been found to encourage a set of good plants, these ought to be preferred. But it is also necessary to consider the soil, and to sow the seeds of such plants as are known to prosper in soils of a similar description. Attention and experience will be found the surest guides in this important point; that from the first, the meadow may be stocked with such plants as may answer every purpose."

We now come to another branch of irrigation, called *warping;* which is one of the greatest improvements that can be exercised, adding to the value and thickness of the soil every time it is repeated. In fact, a new soil is artificially created by the operation to be treated of, and of a quality superior to that of every natural one. It is only in certain situations, however, that warping can be used; but where such an opportunity occurs, it ought never to be omitted. The expense varies according to situation, but can never in the slightest degree be compared with the immense benefit derived from it.

Most rivers are constantly stored with mud and all sorts of alluvial matter; and these being stirred and kept in motion by the tide, are conveyed over such adjoining grounds, as are flat and easily flooded. Embankments, however, are previously required before warping can be executed; and these embankments are made of earth taken from the land, and built with a slope of three feet on each side for every perpendicular foot of rise. There are more or fewer openings in the banks according to the extent of ground proposed to be warped; but, in general, two sluices are only necessary, one called the flood-gate to admit, the other called the clough to let off the water. When the spring tide begins to ebb, the floodgate is opened to admit the water, while the clough is kept close by the flow, or tide. As the tide ebbs down the river, the pressure upon the outside is taken from the clough, when the weight of water admitted by the flood-gate pushes open the clough, and is discharged slowly through it. The cloughs are so constructed, as to let the water run off between the ebb of one tide, and the flow of another; and to this point particular attention is paid. The flood-gates are placed above the level of common tides, it being only the water of spring tides that is admitted.

It will be understood, from what is stated, that warp consists of the mud and salts left by the water that has been admitted; and that the technical phrase *warping*, comprehends all the processes necessary to admit the tide water, and to deposit its sediment upon the field that is meant to be improved. Letting in fresh water would not be called warping, but simply flooding. Fresh water, though useful at proper seasons, would by no means answer the same purpose as river water stirred up by the tide; because it never could furnish a sufficient sediment for thickening the soil; neither would the sediment left be of so rich a nature as what is furnished by tide water.

On Enclosures.—Enclosures, with some trifling exceptions, are formed by building stone walls, or with posts and rails, and sometimes by planting thorn hedges.

To render a stone wall useful as a fence, its height ought never to be less than five feet three inches, otherwise it will not keep in many of the breeds of sheep which prevail in the country. In erecting the fence, great care ought to be

taken to build upon a solid foundation, otherwise the wall is apt to incline to a side and gradually to fall down. The construction of the rail enclosure is so simple as to render a description of it unnecessary.

On Thorn Hedges. A thorn hedge makes an excellent fence, when once trained up and brought to maturity; but the length of time which elapses before it can prove of much benefit, and the great expense incurred in training it up, render such a fence not much cheaper than a stone wall; especially if the loss from the want of it in the first instance is duly estimated. The price of such a fence, however, being gradually expended by the farmer, he is not so sensible of its amount as of that of a stone wall, and is therefore generally disposed to give a preference to the former. If the several expenses belonging to hedges, and the extent of ground wasted by this mode of fencing, are fully considered, we are not certain that the balance will be much in favour of them as fences. At all events, a stone wall is useful in the first year, whereas a dozen at least must elapse before a hedge can be of much benefit.

When a thorn hedge is to be planted it is of advantage to fallow the ground a year before hand; and if the soil is poor, to dress it with dung, so that the young plants may not be oppressed with weeds, or stunted for want of food, when weak and unable to send forth their fibres in search of nourishment. These things being attended to, and the hedge planted, an annual cleaning ought to be given; sometimes two cleanings are necessary before the hedge will thrive. It is also necessary to fence it at the back with paling, that beasts may be restrained from going over it, and to switch it over when two or three years of age, in order that it may be kept close at the bottom. It may be remarked, that a gap once made is never effectually filled up; and therefore the utmost care ought to be exerted to keep cattle of all kinds from making trespasses. As the hedge grows up, repeated cuttings are necessary, so that a wide bottom may be gained, without which no hedge can be considered as a suitable fence; and some attention is required to give a proper shape to the top, which is a matter of much importance to the welfare of the hedge. When thorns are allowed to grow to unequal heights, the strong plants are sure to smother the weak ones; and when the hedge becomes broad at the top, it retains water and snow, to the great injury of the plants. All these evils may be avoided by proper management; though, as we have already said, twelve years must elapse before the best managed hedge can be considered as a sufficient fence; and in many cases double that time must intervene betwixt planting and perfection. Upon many soils, the most arduous endeavours will not make a fence from thorns, though this, after all, depends much upon the attention bestowed at the outset. If once marred in its growth by carelessness and negligence, it is hardly practicable to make up for former errors, by additional diligence. In fact, it is an easier business to root up the old hedge, and train up a new one, than to recover a hedge which has been mismanaged, or suffered to get into bad condition, from want of attention to the cleaning and cutting processes.

Concluding Observations. To give a correct idea of the agriculture of the United States, would require a very considerable volume; since it embraces all the productions of Europe, except wine and oil, and some even of those which are not found there, such as sugar and indigo. Its staple commodities may be numbered under the following heads. Grain of every species produced in the temperate climates of Europe, cattle of every kind, except the buffaloe; sheep, horses, asses, mules and swine, tobacco, cotton, rice, indigo, sugar, flax, hemp, hops, and every species of fruit and legumens reared in any part of Europe.

To treat of the culture of each of these would lead us beyond the limits of this work; we are, therefore, obliged, much against our wishes to omit the consideration of many important articles: nevertheless the foregoing we flatter ourselves, contains such judicious remarks on the theory and practice of the primary branches of agriculture, as, if adopted, cannot fail to redound to the very great advantage of the agriculturist. Those of our readers, however, who are desirous of more comprehensive and detailed accounts of the history, theory, and practice of agriculture, are referred to the American edition of the *Edinburgh Encyclopædia*, Art. AGRICULTURE, and the *Domestic Encyclopædia*. See also ANIMALS, *Domestic*.

ALABASTER. Alabaster is a kind of stone softer than marble, and more easily worked. Its colours are various, but the white is the most beautiful. Some sorts are extremely white and shining; some red, like coral; some of a dark horny colour, resembling onyx; and another sort of a yellowish colour, like honey, variegated with specks and little veins. See GYP-

sum, or *Plaster of Paris*, under the article Agriculture.

ALCARRAZAS, in *Pottery*, are a kind of vessels for cooling wine or water. As they are exceeding porous, the liquor oozes through them on all sides; the air which comes in contact with it, by making it evaporate, carries off the heat contained in the water, &c. in the vessel; thus the liquid remaining in the jar, continues at a temperature considerably below the surrounding atmosphere.

The peculiar convenience attached to these vessels, has introduced them to numerous places in the world, where heat, by causing evaporation, renders the coolness of what is drank greatly to be desired. Thus they are used in Egypt, and other parts of Africa, the East and West Indies, some parts of Europe, Syria, Persia and China.

The manufactory of Alcarrazas possesses recommendations, which most others do not easily admit. The expense of forming establishments for this purpose is very trifling. The process, by which the jars are made, as we shall see below, is very simple and the profits are very certain, when so useful a practice is generally adopted.

The preparation given to the earth may be reduced to three principal operations.

First. Suppose it were necessary to manufacture 150 pounds of earth: after it has been dried and divided into portions of the size of a walnut, it is macerated in a basin or tub, by proceeding in the following manner: The workman takes from 12 to 15 quarts of earth, which are spread out equally in the basin and water, is poured over it; the same operation is to be repeated till the tub is sufficiently full. In pouring on the last water, more is not required than may be necessary to cover the whole mass. In this state, it is suffered to remain 12 hours, when it is to be kneaded by the hands to the consistence of a tough paste. The earth is then to be deposited to a clean tiled form, over which is strewed a little sifted ashes. It is formed into a cake about 6 inches in thickness, which is smoothed at the surface as well as at the sides. It is left in that state till it begins to crack, after which it is freed from the ashes, which adhere to it, and removed to a similar form made exceedingly clean.

Second preparation. To this earth, the workman adds 7 pounds of sea-salt, if he wishes to make jarras, and only half that quantity if it is destined for the formation of botizas or cantaros. This difference arises from the greater or less opacity intended to be given to the vases; the larger the vase is so much the thicker the sides require to be, that it may have the necessary strength; it must also be more porous, as the thickness of the sides increases, which quality depends on the quantity of salt added, the largest requiring more, and the least, less.

The earth is kneaded with the feet, adding the salt gradually, and this labour is repeated at least three times without the necessity of adding more water, as the moisture retained by the material is sufficient.

Third preparation. The earth after being thus subjected to these various manipulations, is now fit to be applied to the lathe. The man who is employed for this work, ought to beat it well with his hands, taking care to extract the stones, as well as every other foreign body. He then forms it into lumps, which he applies to the lathes to be made into vases or jars.

The alcarrazas may be baked in any kind of furnace used by potters; as they require to be only half baked, ten or twelve hours, according to the quantity of fuel, or degree of temperature, is sufficient for the purpose. Care is always taken to choose earth of a proper quality, without ever having occasion to add to it a mixture of sand. The same earth that is used in common pottery, with the addition of salt, is the clay employed for the alcarrazas.

ALCOHOL, or *Spirit of Wine*, is the constant and more characteristic product of the vinous fermentation, produced equally from all fermented intoxicating liquors, by the process of distillation.

Spirit of wine is immediately obtained by distillation from every species of ardent spirits. The latter again, are the products of a previous distillation of any liquor which has undergone the vinous fermentation, so that at least two distillations are requisite to obtain the purely spirituous part of vinous liquors. We shall refer to the articles Distilling, or Distillation, the many important observations to be made on the business of the distillery, and the manufacture of brandy, rum, and malt spirits; and shall here only describe the chemical process of *rectification*, or the preparation of alcohol from these spirits.

The simplest process is the following: Put any quantity of brandy or malt spirits, or rum, into an alembic, join to it the refrigeratory, and distil with a gentle heat. The first product is invariably the strongest and purest. The spirit continues to come over colourless, but gradually diminish-

ing in strength and purity, till at last it is so watery as no longer to take fire by a lighted match. After this, if the distillation be continued, the liquor becomes milky, scarcely spirituous to the smell, and of a sourish taste. In this process no advantage is gained by continuing it after the liquor is no longer inflammable, which happens when about 3-4ths or 4-5ths of the whole contents of the alembic have passed over. If the first fourth or third of the distilled spirit be set apart, it forms a moderately strong alcohol, and the remainder, one more dilute, which will serve for many purposes.

Simple distillation will therefore separate the alcohol of any ardent spirit from the water, colouring matter and accidental impurity; but there are two principles which are not entirely got rid of in this manner; these are, an empyreumatic flavour often given by a careless or too hasty previous distillation of the spirit, and a strong, often fœtid oil, which the spirit has dissolved, either out of the cask in which it is kept, or from some of the materials of fermentation, or from intentional additions by the manufacturer. The flavour of this oil is best perceived on rubbing some of the spirit on the warm hands, whereby it readily evaporates, and a stale nauseous smell, like the breath of drunkards, is left. The mere empyreuma, or burnt smell, goes off in a great degree by keeping in charred casks, but the oil more obstinately adheres.

Alum, sea salt, Glauber's salt, calcined bone, chalk, toasted crumbs of bread, and many other substances have been added, during distillation, to keep down the oil, all of them with considerable but not compleat success.

Alkalies and lime remove it entirely, but with some alteration of the spirit itself, as we shall presently mention.

Beaumé recommends the following judicious management in distillation, to obtain part of the spirit considerably freed from the oil: it is founded on the fact that the first portion distilled contains scarcely any oil, but the latter product is almost saturated with it. Heat brandy in an alembic as usual, and when about a quarter of the liquor has passed, set it aside, and continue the process as long as the spirit is inflammable This latter spirit re-distil as before, separating the first from the last product Still repeat the distillation on the last product of the foregoing process, as long as the first quarter of the product comes over tolerably pure. Then mix all the first products together and distil, reserving the first half for the purest alcohol, and the last for ordinary purposes. Thus the oil is constantly concentrated into the latter distilled portions, whilst the first are obtained proportionably purer.

We have mentioned that simple distillation of alcohol, however often repeated, and only the first product reserved, will yield a spirit of the specific gravity of about .825 at 60°, but the highest concentration is given by the use of alkalies or lime, or in some degree by any salt which has a very strong affinity with water; and the two former have the additional advantage of destroying the empyreumatic oil, though the alkalies are apt, in return, to communicate somewhat of an urinous flavour.

Though both the carbonated and caustic alkalies have the effect of concentrating alcohol, a difference takes place in their action on this liquid. The carbonated alkalies are insoluble in the spirit, but the caustic alkalies compleatly dissolve in it. If to a weak spirit is added some dry carbonated potash, and shaken together, the alkali becomes dissolved only in the water of the spirit, and thus two liquors appear of very different specific gravity, and absolutely immiscible by agitation. The lower liquor is the alkaline solution, the upper the alcohol, now rendered stronger by the loss of the water, which the alkali has separated from it. If the alcohol alone be poured off, and mixed with a fresh quantity of dry carbonated potash, the alkali will again either entirely dissolve, or become pasty, according to the quantity of superfluous water left in the spirit; if there is none, it will remain at the bottom untouched.

This is a ready way of bringing alcohol to very great concentration without distillation, and would answer every purpose, if it were not that the dry carbonated alkalies (except the crystallized) all contain a certain portion of the salt, in a state sufficiently approaching to causticity to be soluble in alcohol; so that, in the above process, the liquid swimming above the watery solution of carbonated potash, is not pure spirit, but a very weak solution of caustic alkali in alcohol. To obtain it quite pure, add one part of very hot dry carbonated potash (good pearl-ash will do) to about six or eight parts of alcohol, already brought to considerable strength by distillation, let them stand together for some hours, frequently shaking them; then distil with a gentle heat, and the first half or two-thirds of the product is the purest alcohol.

Or, with less trouble, add one part of

 ALC

the alkali to four parts of brandy, and distil, after standing together for about a day: but the former process is the best.

Burnt alum, dried Glauber's salt, or decrepitated common salt may be very conveniently substituted for the carbonated alkali.

Hot, dry, caustic alkali is still more efficacious in separating the water from the alcohol, which, carefully distilled, is extremely pure. But caustic alkalies, as well as lime, decompose so much of the alcohol, as to render it both a wasteful process and one that requires more care in conducting it.

By the above means the levity and proportionable dephlegmation of alcohol may be brought from the specific gravity of .825 at 60° of heat, to about .813° or perhaps still lower. Malt spirits yield as strong and pure an alcohol as wine, brandy, or other spirits.

Various methods have been employed for ascertaining the strength of ardent spirit, but this is attended with more difficulty than might at first be imagined. Long habit will enable a person to judge with tolerable accuracy by the taste, and the frothiness and size of the bubbles when shaken, but this is obviously liable to error. The test of burning the spirit has long been used, and, with proper precaution, it may be brought to some degree of accuracy. It has been already mentioned, that a very pure alcohol will burn away without leaving any residue, and that the weaker the spirit is, the more water will be left after combustion. In many countries this trial is actually performed in the following simple manner. A cylindrical silver cup, properly graduated and made for this purpose, is filled to a known height with the spirit, which is then kindled, and is suffered to burn till the flame goes out, after which the quantity of watery residue is noted. Pure alcohol leaves none, rectified spirit of moderate strength about 25 per cent, French brandy about 56, common good malt spirit about 65, and the like. The principal imperfection of this method, is the difficulty of always performing the experiment under similar external circumstances: and besides, it is by no means proved that the combustion of compound spirits will follow the same rules as that of simple mixtures of alcohol and water. In this trial the residue still contains a portion of alcohol, the combustion ceasing before all the spirit is burnt off; but on the other hand, some of the water must necessarily have been evaporated by the heat of combustion.

Another trial, though extremely incorrect, is to pour a few drops of the spirit on a very small heap of gunpowder, and kindle it. The spirit first burns as usual, and when the last portion is burning off, the powder explodes, if the spirit has not been too watery to leave the powder very damp. Cotton wool burns in like manner at the end of the combustion of the spirit, if not too damp. But it is well known that a little heap of powder drenched with even a strong spirit, will not take fire, and a large heap will explode if only a few drops of a watery spirit is used. Besides, these tests, were they accurate, would only indicate two degrees of strength, that which would fire the powder, and that which would not.

Another test, sufficiently accurate for a rough estimation of the strength of the spirit, is to shake it in a bottle with some dry carbonat of potash, and to judge of its strength by the quantity of water which the alkali attracts from it.

A spirit that swims in olive oil has sometimes been considered as proof, and this method is actually used in the manufacture of rum, but this test also only indicates two degrees.

The only mode of ascertaining the relative strength of every species of ardent spirit, with any considerable accuracy, has been by determining its specific gravity; and the high public importance of the subject in countries where the consumption of spirits adds a vast sum to the public revenue, has been the means of instituting many very interesting series of experiments to this purpose.

As our limits will not allow a complete notice of all that has been done on this subject in different countries, we shall confine ourselves to the very minute, accurate, and every way excellent series of experiments made for the Board of Excise in London, by Sir Charles Blagden, assisted by Mr. Gilpin, and published in the 79th and 82d volumes of the Philosophical Transactions.

Their object was to determine, by actual experiment, the specific gravity of mixtures of different proportions of alcohol of a determinate strength, with pure distilled water at different degrees of the thermometer; and these experiments were carried to a minuteness much more than necessary even for the high duties now levied on spirits, where a trifling difference in strength becomes an object of attention.

It is assumed as a principle in the present mode of laying the duties, that all kinds of distilled spirits contain an equal proportion of real alcohol with a mixture of pure alcohol and water, brought to the

same specific gravity, and therefore it is on the absolute quantity of alcohol in any mixture that the duty is levied. This position though sufficiently accurate for the purposes of the revenue, is not absolutely true; since ardent spirit will dissolve various substances, such as sugar, colouring matter, &c. the effect of which solution will be to increase its density, and therefore to make it appear to contain less alcohol than is really the case.

The whole expansion of alcohol as pure as simple distillation will give, when raised from the temperature of 30° to 100° is about one-twelfth of the bulk which it had at 30°; and, within this range, the expansion is pretty equal for equal increments of heat. On the other hand, the expansion of water within the same range of from 30° to 100° is only one hundred and forty-fifth of its bulk at 30°. Besides, a curious property of water, discovered by Dr. Blagden, here comes into action; which is, that (contrary to the nature of all other known liquids) it has arrived at its greatest density much before it is cooled down to its freezing point, namely at 40° or 42°, and that between this temperature and 30° its specific gravity regularly goes on diminishing till congealed. So that the gravity of water at 30° is found to be no more than at 48 1-2°.

When alcohol and water are mixed, a mutual penetration of the two liquors takes place, as we have already mentioned, and the liquors occupy less room mixed than separate, so that the specific gravity of the mixture is greater than the mean specific gravity of the two, before mixture. The anomaly in the action of heat on water below 42° has just been noted, but another source of complication in calculating the densities of spirit and water, arises from the following circumstance: with a heat gradually raised from 42° upwards to 100°, water at first expands slower in comparison to its entire increase, than alcohol; but afterwards, when approaching to the highest term of heat, its expansion is proportionably greater than that of alcohol. Hence it is that a mixture of these two liquids will approach the nearer to the progressive ratio of expansion of the one or of the other, in proportion as one or the other liquor predominates in the mixture. But, again, the absolute expansion will be greater as there is more alcohol in the mixture.

All these circumstances indicated the danger of trusting to mere calculation from a very few data (as had been done by other scientific persons) to compose tables of the expansion of alcohol and water, with even tolerable correctness; and hence Sir C. Blagden, and his coadjutor, determined to undertake so many actual experiments on the specific gravity of mixtures of alcohol and water, at various temperatures, as to leave but very little room for incorrectness in the spaces on the scale filled up by interpolation. The pure, or standard alcohol, was that of .825 at 60°, being the purest obtainable by simple distillation, lowered a very little by water to bring it to even numbers for the convenience of calculation. The specific gravity was taken, in every case, by filling the same bottle to a known height with the spirit, and weighing it. To ensure a perfect penetration of the spirit and water, they were never used till they had been mixed for a month, and often shaken. The extreme precautions taken to ensure as great accuracy as human instruments can command, are given in detail in the original memoirs. The actual experiments were, the specific gravities, first of the pure spirit, then of 100 parts of it (by weight) with every five parts of water, from 5 to 100, and lastly of 100 parts of water with every five parts of spirit; all of them taken at every fifth degree of heat, from 30 to 100. The intermediate degrees, both of temperature and of proportion of water or spirit, are filled by interpolation.

The following Table, extracted from Mr. Gilpin's corrected tables, in the 82d vol. of the *Philosophical Transactions*, will apply to most cases which may be wanted in chemical enquiry.

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Table of the Specific Gravity of Mixtures of Alcohol and Water at different temperatures.

One hundred parts (by weight) of pure Alcohol with

Heat	Pure Alcohol.	5 Water	10 Water	15 Water	20 Water	30 Water	40 Water	50 Water	60 Water	70 Water	80 Water	90 Water
40°	.83445	.84539	85507	.86361	.87134	.88481	.89617	.90596	.91428	.92151	.92783	.93341
45	.83214	.84310	.85277	.86131	.86907	88255	89396	.90380	.91211	91937	.92570	93131
50	.82977	.84076	.85042	.85902	.86676	.88030	.89174	.90160	.90997	.91723	.92356	.92919
51	.829 9	.84028	.84994	.85855	.86629	.87984	.89128	.90115	.90952	.91679	.92316	.92877
52	.82881	.83980	.84946	.85808	.86582	.87937	.89083	.90069	.90906	.91634	.9 274	.92835
53	82833	.8393	.84898	.85760	.86535	.87890	.89037	.90024	.90860	. 1590	.92231	.92793
54	.82784	.83883	.84859	.85712	.86488	87843	.88991	.89978	.90814	.91546	.92189	92751
55	.82736	.83834	.84802	.85664	.86441	.87796	.88945	.89933	.90768	.91502	.9 145	.92707
56	.82689	83787	.84756	.85618	.86395	.87750	.88900	.89887	.90724	.91459	92102	.92666
57	.82642	.83740	.84709	.85571	.86348	.87704	.88855	.89842	.90681	.91416	.92059	92625
58	82594	.83693	.84662	.85521	.86302	.87659	.88810	.89797	.90638	.91373	.92019	.92583
59	.82547	83646	.84615	.85477	.86256	.87614	.88795	.89752	.90595	.91330	91975	.92541
60	.8 500	.83595	.84568	85430	.86208	.87569	88720	.89707	.90549	.91287	.91933	9 499
61	82453	.83552	.84520	.85382	.86162	.87523	.88674	.89662	.90504	.9 242	.9 890	.92455
62	82405	.83504	.84473	.85335	.86115	.87476	.88628	.89617	.90460	.91198	.91847	92412
63	.8 357	83457	.84426	.85288	.86069	.87430	.8858	89571	90416	.91154	.91803	.92369
64	.82310	83409	.84379	.85 41	.86022	.87384	.88536	895 5	.90372	.91110	.91759	92326
65	.82262	83362	.84334	.85193	85976	.87337	88490	89479	.90328	91066	.91715	.92283
66	82214	.83315	.84286	.85145	.85928	87291	.88443	.89433	.90284	.91023	.91670	.92241
67	82167	83268	84237	85096	.85880	.87245	.88395	.89387	.90239	90978	.91625	.92198
68	.82119	.83221	.84189	.85048	.8583	.87198	.88348	.89342	.90194	.90934	.91581	.92155
69	.82071	.83173	.84141	84999	.85784	.87151	.88301	.89297	.90149	.90890	91537	92112
70	.8 023	83124	.84092	.84951	.85736	87105	.88254	89252	.90104	.90847	91493	92662
75	.81780	8 878	.83851	.84710	.85496	.86864	.88018	.89018	89872	.90617	.91270	.91849
80	.81530	.82631	.83603	.84467	.85248	.86622	.87776	.88781	.89639	.90385	.91046	.91622

One hundred parts (by weight) of Water with

Heat	100 Alc.	90 Alc	80 Alc.	70 Alc.	60 Alc.	50 Alc.	40 Alc.	30 Alc.	20 Alc.	10 Alc.
40°	.93827	.94295	94802	.95328	.95879	.96434	96967	.97472	.98033	.98795
45	.936 1	.94096	.94605	.95143	.95705	.96280	.96840	.97384	.97980	.98774
50	.93419	.93897	.94414	.94958	.95534	.96126	.96708	97284	97920	.98745
55	.93208	.93696	94213	.94767	.95357	.95966	.96575	.97181	97847	.98702
60	.93002	.93493	.94018	.94579	.95181	.95804	.96437	.97074	.97771	.98654
65	.92794	.93285	.93822	.94388	.95000	.95635	96288	.96959	.97688	.98594
70	.9 580	.93076	.93616	.94193	.94813	.95469	.96143	.968 6	.97596	98527
75	.92364	.92865	.93413	.93989	.94623	.95292	.95987	.96708	.9749	.98454
80	.92142	.92646	.93201	.93785	.94431	.95111	.95826	.96568	.97385	.98367

Besides the specific gravities here given, the original tables contain several particulars deduced from the experiments, such as the quantity of real spirit in a given bulk of the mixtures, the actual condensation expressed in numbers, and the like. Some of these chiefly concern the business of the exciseman, but with regard to the condensation, we shall extract the following results deduced from the same tables.

One hundred parts, in bulk, of the pure spirit, at the temperature of 60°,

	of water		parts			
mixed with	25	*diminish in bulk*	2.31	*being about*	$\frac{10}{541}$	*of the whole before mixture*
	50		3.76	. . .	$\frac{10}{400}$	
	75		4.82	. . .	$\frac{10}{363}$	
	100		5.60	. . .	$\frac{10}{357}$	
	125		6.15	. . .	$\frac{10}{365}$	
	150		6.53	. . .	$\frac{10}{382}$	
	175		6.76	. . .	$\frac{10}{406}$	
	200		6.81	. . .	$\frac{10}{440}$	

Hence it appears that the greatest diminution in bulk, or concentration, *in proportion to the quantity of ingredients*, which takes place between alcohol and water, occurs, when equal bulks of each are used, being more than a thirty-sixth of the whole; but the greatest possible diminution obtainable by any admixture of water, happens when two parts of water are added to one of alcohol, being 6.81 parts where 100 of alcohol are employed. This last is the highest term of *actual* diminution, as it is again less than 6.81 in 100, if still more water is added.

Alcohol is a most powerful antiseptic, and it exerts this power upon every substance, animal or vegetable, capable of fermentation or spontaneous change.

The uses of alcohol in its various forms are very numerous and important. As the intoxicating basis of all vinous or spirituous liquors, it is only employed in the intermediate state of distilled spirits. In the arts it forms a most important ingredient in many varnishes; in pharmacy it is the liquid component of tinctures and other preparations; it preserves from corruption all the wet preparations of the anatomist; and to the chemist it is an invaluable agent, operating on a great number of substances for which no other proper solvent could be found, and at the same time altering their nature so little as to exhibit them nearly in their original state when expelled by evaporation. Many other less important uses might be mentioned, such as filling thermometers, and another of great advantage in nice chemical operations, is that, as a combustible, it affords a gentle steady flame, unfouled by smoke or any vapour which can obscure the sight of the process which is going on in the vessel so heated. See Nicholson's *Chim. Dictionary*, Art. ALCOHOL, for a further account of this subject.

ALE, a fermented liquor, made from malt and hops. This drink was originally made in Egypt, where it supplied the want of liquors prepared from the grape; and has been a favourite beverage in almost all countries. For the facts connected with the history of this liquor, see Hume's *History of England*, vol. ii. p. 224; and Pinkerton's *Geography*, vol. i. p. 65. On the salubrity of ale, see Cullen's *Materia Medica*, vol. i. p. 418. See also BREWING.

ALKALIES and ALKALINE EARTHS. The class of alkalies is amongst the most ancient in chemical science, and one which has stood its ground through all the changes occasioned by modern discoveries, though with some modification.

The original application of the term *alkali* (which is of Arabian origin) was to express the acrid saline residue left in the ashes of the plant *kali*, after its combustion in open air. This was also very early known to the Greeks and Romans; by the latter termed, *lixivial*, which term is still retained, *lixivium*, or *ley*, meaning, properly, the soluble salt extracted out of vegetable ashes by the addition of water. From the circumstance of the ashes being the fixed or unvolatilized part of the plant, the rest having been dissipated by the combustion, the lixiviary salt was also called *fixed* alkali, a term still in universal use. The proper fixed alkalies are of two kinds, the vegetable or *potash*, and the mineral or *soda*; the latter is found, often native, in immense quantities, being the basis of rock salt, and is also the principal saline residue of many plants growing on the sea shore; and the former is contained in, and almost entirely procured from, the

ashes of vegetables in general, not growing contiguous to the sea. See the articles POTASH and SODA.

Again, as the volatile ammoniacal salt procurable from most animal substances, also of great antiquity, was found to agree with the other alkalies in taste, and in many chemical properties, though not in fixity, this ammoniacal salt was also termed an alkali, but *volatile*, in opposition to the two former, which remain unaltered in very considerable heat, and are therefore, comparatively, *fixed*.

Of late years, some of the earths (especially barytes and strontian, which were unknown to antiquity) having been found to possess alkaline properties in no ambiguous degree, these have been by some chemists absolutely associated with the alkalies; by others have received the term *alkaline earths*, to express this resemblance, which, in the two above mentioned, almost amounts to identity of properties; but in the two others, lime and magnesia, the agreement is only partial.

As it is but of little consequence which arrangement be adopted, provided an uniformity be observed, we have throughout the present work restricted the term *alkali*, to the three ancient salts of that name; the two *fixed*, potash and soda, and the *volatile*, ammonia. Under the appellation *alkaline earth*, we include the following, Barytes, Strontian, Lime, and Magnesia.

We shall now enumerate the properties usually described as belonging to alkalies.

The taste of an alkali is acrid, burning, and nauseous. It acts with so much energy and rapidity on the tongue, as to destroy, if concentrated, the skin of the part which it touches, and hence its extreme causticity. The three alkalies possess this in the highest degree, being more rapidly soluble than the earths, and of the latter only barytes, strontian, and lime, exhibit this corrosive taste, magnesia being absolutely insipid.

All the alkalies, except ammonia, are without smell, or nearly so: a particular urinous odour however arises during the solution, with heat, of the other alkalies and earths, magnesia excepted.

The alkalies are extremely soluble in water, barytes and strontian in considerable quantity, lime, sparingly; magnesia scarcely at all.

Of all other bodies they possess the strongest affinity for acids, uniting with them generally to such a degree as to produce perfect neutralization, or such a state of union, that the characteristic properties of both acid and alkali are lost, and new ones acquired. Most of the combinations with acids are considerably soluble in water, and all crystallizable with more or less ease.

Lastly, they all produce certain changes on some vegetable colours; and this test is perhaps the most striking of all above enumerated, since it is possessed by all without exception, though with some variety. The blue colours of many plants are changed by them to green, of which the syrup or tincture of violets, affords a ready instance; many of the reds, such as that of logwood and litmus, are changed into violet; and the yellow of a great many plants, such as turmeric, rhubarb, or liquorice root, is changed to a brown, or dirty brick red.

It appears therefore, that there is scarcely a single characteristic except the change of certain colours, that will apply equally to all the alkalies and alkaline earths, but yet the general resemblance is so great as to justify this classification. Magnesia alone has the least claim to the title of an alkaline earth, and yet its affinity to acids is strong, and its power of changing some of the vegetable colours is very considerable. See EARTHS.

ALKANET, a colouring root, cultivated in many parts of the south of Europe, and brought in small quantities from the Levant. The plant grows to about a foot in height. The root, which is the part used as a dye, is as big as the thumb, red without and white in its inner part. The outer red portion is alone used for colouring. It grows in abundance in Languedoc, in dry sandy soils. The root is dried in the sun, and undergoes no other preparation. When good it is somewhat elastic though dry, of a deep red without, and should stain the finger nail freely when rubbed upon it, wet or dry.

Alkanet root imparts its deep red colour very freely to spirit of wine, the essential and fixed oils, wax, fat, and any other unctuous substance; and hence it is of considerable use in making some of the coloured oils or varnishes. To give a red colour to wax, for example, melt it, and infuse small pieces of the root in it for a few minutes, till it has acquired the requisite colour; when, if it be applied to warm marble, it impresses a durable stain of flesh colour into the stone.

ALUM is a crystalline salt, of a sweetish acidulous taste, and extremely astringent; and is by far the most important of all those with earthy bases. We shall, therefore, treat of it at considerable length.

Alum is produced but in a very small

quantity, in the native state; and this is mixed with heterogeneous matters. The greater part of this salt is factitious, being extracted from various minerals called alum ores; such as sulphureted and pyritaceous clay, shale or bituminous alum ore, and volcanic aluminous ore. It might also be extracted from many species of pyrites, but so contaminated with iron as to scarce pay the expense of operation.

The simplest process by which alum is prepared is that in use at the Solfatara, near Naples.

The Solfatara, called by the ancients Forum Vulcani, Campi leucogei, is a small plain on the top of a hill, covered with a white soil, which being penetrated and entirely impregnated by sulphureous vapours, forms a rich ore of alum, as may be ascertained by its strong styptic taste when applied to the tongue. In order to extract the salt, a shed is erected, in the middle of which is placed a large oblong leaden cistern, let into the ground almost up to the brim, in order to receive a proper quantity of the subterranean heat: this cistern is surrounded by smaller cauldrons, let into the ground in the same manner. When all is prepared, the extraction of the alum is effected by putting some of the aluminous earth into the cistern, and pouring water upon it; this mixture is carefully stirred, till the whole of the salt is dissolved; after which, the earth being removed, a fresh portion is put in, so as to bring the water almost to a state of saturation. The liquor is now removed into the smaller cauldrons, and the loss by evaporation is supplied by fresh liquor, till a pellicle begins to appear on the surface. It is then removed into tubs, where, as it cools, it deposits a large quantity of crystals of alum. The mother liquor is returned to the cistern, where it is mixed with earth as before. The crystals of alum are purified by a second solution and crystallization, after which they are fit for the market. Hence it appears that the alum exists ready formed in the earth of the Solfatara, and that the whole of the manufacturing part is reduced merely to lixiviation and purification. This alum, from the careless method of preparing it, is considerably fouled by sulphat of iron, or copperas, and is in consequence little known beyond the Neapolitan territories.

The alum works of La Tolfa, near Civita Vecchia, in the Roman state, are among the oldest in Europe, and as the alum manufactured here is reckoned the purest of any, we shall give a detailed account of the process, as reported by the Abbé Mazers and Fouzeroux de Bouderoy.

The ore made use of at La Tolfa, is procured about a mile off the place where it is manufactured. It is found in irregular strata, and deep, almost perpendicular, veins in the side of a hill; and when unmixed with other substances, is of a yellowish white colour, and so hard as to require blasting by gunpowder. Being broken into pieces of a moderate size, it is first of all roasted. The furnace made use of for this purpose is a cylindrical cavity in a mass of masonry, the greater part of which is occupied by a hemispherical dome, with a large round aperture in its top. The fuel, which is wood, is conveyed by a side door into the dome, and the alum ore is piled skilfully over the aperture, so as to form a smaller dome, whose diameter is equal to that of the aperture in the lower one. As soon as the fire is kindled, the smoke and flame penetrate through the interstices of the pieces of ore, and quickly heat the whole mass. For the first three or four hours, the smoke escapes in dense black volumes, but by degrees it acquires a whiter colour, the pieces of ore become of a light red or rose colour, and a faint smell of liver of sulphur becomes manifest. At the end of twelve or fourteen hours the fire is extinguished, and when the alum stones are grown cool, they are taken down, and again arranged in the same manner as before, only observing to place those pieces near the centre of the fire which were before at the sides, that the whole may be equally calcined. The second roasting continues nearly as long as the first, and the stones are considered to have been properly managed if they are of an uniform white colour, and considerably styptic when applied to the tongue.

The second process commences by piling the stones upon a smooth sloping floor, in long parallel ridges, between each of which is a trench filled with water; from this trench the beds are frequently sprinkled, in proportion as they become dry by the action of the sun and wind. After a few days the pieces of roasted ore begin to swell and crack, and fall to powder like quick lime when it is slacked, acquiring at the same time a light reddish colour; and at the end of forty days, more or less, this operation is completed. Its success is materially influenced by sunshiny weather, the hottest periods of the year producing the best alum, and in the largest proportions, while long-continued rains entirely exhaust and spoil the ore.

The next stage of the manufacture consists in dissolving the alum out of the ore, and disposing it to crystallize. For this purpose a leaden boiler is filled two-thirds with water, and portions of the decomposed ore are successively stirred in, till the vessel is nearly full: when the liquor begins to boil it is diligently stirred up from the bottom, that the whole of the alum may be dissolved, and the waste by evaporation is supplied from time to time by the mother water of a preceding crystallization At the end of about twenty-four hours the fire is extinguished, and the liquor is left at rest for the particles of earth to subside: as soon as this has taken place, a stop-cock, fixed in the side of the boiler, about one-third of its heighth from the bottom is opened, and the clear solution is transferred along a wooden spout, into square wooden reservoirs, seven feet high by five wide. so constructed as to be readily taken to pieces; in these it remains about a fortnight, during which time the alum crystallizes in irregular masses upon the sides and bottom. The mother liquor is of a flesh colour and unctuous appearance, and still rich in alum; it is therefore transferred into shallow receptacles, where it deposits, after a time, both earth and crystals; these latter are taken out and separated from the impurities by washing in the residual fluid. Finally, this fluid itself is let out into a deep reservoir, whence it is pumped, to be mixed with fresh water and earth in the leaden boiler, as already mentioned. The earth, after having been once lixiviated, is thrown away, although by simple boiling with sulphuric acid, it may be made to yield a considerable quantity of pure alum.

Hitherto we have noticed only those ores which afford alum without the addition of potash or ammonia: by far the greater part however of the European alum is prepared from the aluminous slate (Alaunschiefer) or the aluminous earth (Alaunerde) and as these minerals contain only the remote principles of this salt, a much more complicated process is required than where the alum exists ready formed in the ore. The only necessary ingredients in the pyrito-aluminous ores are clay and pyrites, or sulphuret of iron; in addition however to these, there is always a variable proportion of bitumen, lime, and magnesia.

The first process in the manufacture of alum from the pyritous ores, is the acidification of the sulphur, and the formation of sulphat of alumine: to effect which the common practice is to roast the ore as soon as it is procured from the mine. Upon a hard floor of rock, or well rammed clay, is laid a bed of faggots and coal, which is covered all over to the thickness of two or three feet with pieces of ore: fire is now applied, and as the heat penetrates through the mass, fresh quantities of ore are added, till the pile attains the heighth of thirty or forty feet. In Sweden, where they lixiviate the same parcel of ore repeatedly, the pile is built up with alternate strata of fresh ore, and that which has already been used one, two, or three times. In two or three months the fire goes out of itself, and the ore, if properly roasted, will be of a brown colour, and astringent to the taste: a red colour indicates that the heat has been too great, and the produce of alum is considerably diminished. The most judicious method, however, of preparing the ore for lixiviation, is that practised at Flone, in the department of l'Ourte, in France. When procured from the mine, it is sorted, according to its degree of hardness, and laid lightly in heaps ten or twelve feet high, which are sedulously watered during dry weather, as a certain degree of moisture greatly hastens this part of the process. The spontaneous decomposition of the pyrites, which is thus brought about, is very slow, the hardest kinds of ore requiring from three to four years. When upon examination the mass appears sufficiently impregnated with salt, the contents are made into a pile, with alternate strata of faggots, and by a very judicious and gentle roasting, the sulphat of iron is for the most part decomposed, and its acid, uniting with the alumine and the potash produced by the combustion of the wood, forms alum. After the ore has been prepared by one of the methods above mentioned, it is lixiviated. For this purpose large receptacles of wood, or masonry, furnished with a double bottom and stop-cock, are nearly filled with the ore; upon which water is poured in various proportions, according to the custom of the manufactory or the supposed richness of the materials. The most economical method is to let the water remain for twelve hours in the first reservoir, containing ore that has been already twice lixiviated; then to transfer it for an equal time to that which has been once lixiviated; and last of all to mix it for the same number of hours with fresh roasted ore; after which it is turned into a large vat, where the earthy sediment is for the most part deposited. The liquor is judged to be sufficiently strong if its specific gravity is one-eighth greater than that of pure water.

The boiling down succeeds to the lixi-

viation, and is always performed in leaden vessels, copper being for the most part too dear a material, and iron being attended with the inconvenience of decomposing the alum in a considerable degree. The object in boiling is two-fold, first to evaporate a part of the water, and thus induce the salt to crystallize, and secondly to decompose the sulphat of iron. The lixivium being mixed with the mother water of a former crystallization, is boiled for twenty-four or forty-eight hours, according to the concentration of the liquor; during which much selenite and oxyd of iron is deposited, forming a crust at the bottom of the pan, that requires to be removed from time to time.

In Saxony, where the proportion of mother water is large and the lixivium is brought to a high degree of concentration, the boiling continues without interruption for a week. At the end of these respective periods, the specific gravity of the liquor is assayed by a leaden hydrometer, or by filling a bottle of known size with the liquor, and then ascertaining by the balance the comparative weight between it and water. This being done, an alkaline solution is added, and the first crystallization is brought about. In the Saxon manufactories, where the liquor is uncommonly concentrated, as soon as the evaporation is finished, the contents of the boiler are let out into a reservoir, where they are strongly agitated for half an hour, during which time a certain proportion of soap-makers lees and putrified urine is added. At Saarbruck, the potash is added twelve hours before the boiling is finished. In the English works, when the liquor appears by the hydrometer to be sufficiently evaporated, the fire is withdrawn from the boiler, and a stream of impure alkaline lixivium, from kelp and soap-makers ashes, is let into the liquor already in the boiler; at the same time the cock of the boiler is turned, so as to allow the contents of it to flow into a reservoir, by which management the two liquors are speedily and effectually mixed. It remains in this reservoir for three hours, during which it deposits an earthy and ferruginous sediment, and becomes of a clearer colour; it is now transferred to another large vat, and has its specific gravity again taken, according to which a greater or less quantity of putrid urine is added, to lower it to the required standard; being then agitated briskly for a quarter of an hour it is left at rest, and in the course of five days the crystals are deposited on the sides of the vessel. In some French and Swedish manufactories, the liquor, after being boiled down, is merely agitated for some time, without adding any alkali, and then passed into the crystallising tub. The rough alum, or of the first crystallization, is always contaminated by a small quantity of sulphat of iron, from which it is mostly freed by washing in cold water, the latter salt being far more soluble in this fluid than the former. When washed it is ready to be refined: for this purpose a few hundred weights of alum are put into a pan, with as much soft water as is just sufficient for its solution when boiling hot; after the solution is effected, some bullock's blood is added, for the purpose of clarification; and at the end of about six or eight hours, when the alum is held in solution by only a little more fluid than its own water of crystallization, the liquor is run into casks, where it concretes almost entirely in a single mass. After ten or twelve days, the residual liquor is poured out, and the salt being broken into pieces of about a hundred weight, is ready for sale.

The only manufacture of alum which has been conducted throughout on strict chemical principles, is that established some years ago by Chaptal, at Javelle, near Paris, with which we shall terminate our account of the modes of preparing this important salt.

According to the modern way of preparing Sulphuric Acid, the requisite proportions of sulphur and nitre being mixed together, are brought to combustion in a close chamber lined with lead: the sulphur is thus acidified and converted to vapour, which, by degrees, unites with the water with which the floor of the chamber is overspread, and forms a diluted sulphuric acid. A similar process was established by Chaptal, only substituting dried clay for the water, the result of which was so favourable, that a large manufactory on the same plan was set on foot, which has continued in full activity for several years, producing alum inferior only to that of La Tolfa.

The chamber in which the combustion is carried on is 91 feet long, 48 feet wide, and 31 feet in heighth, to the pitch of the roof. The walls are of common masonry, lined with a moderately thick coating of white plaster: the floor is a pavement of bricks, set in a mortar composed of equal parts of baked and unbaked clay; and this first pavement is covered by a second, the bricks of which are placed so as to lie over the joints of the lower one, and are themselves firmly connected to each other by a cement, composed of equal parts of pitch, turpentine and wax, made boiling hot, and poured between

the joints instead of mortar. The roof is of wood, and the beams are set at much less distances than common; they are also channelled with deep longitudinal grooves, for the purpose of receiving the planks that fill up the space between the beams, so that the whole of this great area of carpentry does not present a single nail. The chamber thus constructed, was covered on the sides and top with a layer of the cement just mentioned, applied as hot as possible, so as to penetrate into all the pores of the wood and plaster; three more successive layers were then laid on, and the last was polished, so as to present an uniform even face. In order to prevent the wood-work of the cieling from warping, it was covered on the outside with a thick coating of cement, and a light roof of tiles was laid over the whole. By substituting this cement for a lining of lead, a vast saving was effected in the first expence; and it has been found by long experience to require fewer repairs than even lead itself.

The clay made use of is of the purest kind, such as pipe-clay, that it may contain neither lime nor magnesia, and as little as possible of iron. It is to be tempered with water, and made into balls, five or six inches in diameter: these being dried in the sun are afterwards calcined in a furnace: the first effect of the heat is to blacken them; but soon after they become red hot the carbonaceous matter which causes the blackness is burnt out. Being withdrawn from the fire and cooled, they are broken down into small fragments, and spread over the floor of the chamber. In this state they are exposed to the vapour of sulphuric acid, from the combustion of sulphur and nitre, and in a few days the pieces are observed to crack and open, and to be penetrated with slender saline crystals. The earth being at length covered with efflorescences, it is removed from the chamber and exposed to the air, under shelter of a shed, that the acid may be completely oxygenated and become thoroughly united with the earth. It is now lixiviated, and the liquor contains in solution little else than acidulous sulphat of alumine: this being boiled down to the proper consistence, a solution of acid sulphat of potash (being the residue in the pots of combustion, from which the sulphuric acid was produced in the chamber, and consisting of the alkaline base of the nitre, combined with some of the sulphuric acid) is poured in; and the liquor being then transferred into a large vat, perfect crystals of alum are deposited, which are afterwards refined in the usual manner.

The advantages of this process are numerous. It may be carried on wherever a proper supply of clay can be had. The space taken up by the works is much less extensive than what is required according to the common methods. The whole manufacture is performed in at most one third of the time usually necessary. A large quantity of fuel is saved; the extraneous salts in the mother water are fewer; an important use is made of the residual sulphat of potash; and lastly, the alum itself is much purer than usual, and almost equally well adapted to fix the delicate dyes as that of La Tolfa, the commercial price of which is generally about double that of the English alum.

The uses of alum are various and important. It is an article of the Materia Medica; it is a necessary ingredient in most kinds of pigments and lake-colours, and in the various processes of dyeing. All leather that is not tanned or dressed with oil is prepared for use by means of alum. It is used by candle-makers to harden their tallow and render it white; and an unauthorized use is occasionally made of it by bakers in the preparation of the finest white bread. See Abbe Mazers, and Fouzeroux de Bouderoy, in the *Mem. de l' Acad des Sciences*, vol. v. p. 389.

ALUMINE. See EARTHS.

AMADOU. A combustible preparation, applied to the same uses on the continent as tinder is among us. It is made chiefly in Germany, whence it is imported in large quantities to France. The basis of the amadou consists of the large spungy boleti that are found on the trunks of old oaks, ashes, and various other kinds of timber trees. As soon as gathered, they are boiled in plain water, to extract all the peculiar juices; this being done they are dried, and then well beaten with a wooden mallet, in order to render them soft: they are also by this means stretched, so as to be reduced to the thickness of strong buff leather. A boiling hot solution of nitre is now prepared, in which the boleti are immersed for a short time; they are then taken out, drained, and finally dried in an oven. Good amadou is of a yellowish brown colour; is soft to the touch like the finest felt, perfectly pliable, tough, and somewhat elastic It takes fire like tinder, by a spark from the collision of a flint and steel, and burns slowly but is very difficult to extinguish.

AMALGAM. This name is applied to the combination or mixtures of mercury with other metals. Amalgams are applied to a considerable number of useful purposes. . The amalgam with gold is used in the process called water gilding, in which

the mercury serves in the first place as the medium of adhesion between the gold and copper, and is afterwards drawn off by heat. See GILDING. Looking glasses are silvered by an amalgam of tin. See SILVERING. The amalgam of zinc, triturated with tallow, is found to assist the excitation of electricity by the friction of a curtain against glass, in a wonderful degree.

AMBER. This is a pellucid and very hard inflammable substance, of one uniform structure, a bituminous taste, very fragrant smell, and highly electric.

The generality of authors contend for this substance being a bitumen, which trickling into the sea from some subterraneous sources, and then mixing with the vitriolic salts, that abound in those parts, becomes congealed and fixed. However, as good amber is found by digging a great distance from the sea, it is probable that it is a bitumen of the naphtha or petroleum kind, hardened into its present state by a vitriolic acid, or oil of vitriol.

The natural colour of amber is a fine pale yellow, but it is often made white, and sometimes black; in both cases, it is rendered opaque, by the admixture of extraneous bodies. The most frequent variation, however, from the yellow, is into a dusky brown. Sometimes it is tinged with metalline particles, and remains pellucid.

The salt, oil, and tincture of amber, have been variously applied in medicine; but its mechanical use for toys, beads, cabinets, and utensils, and the better sorts of varnishes, are of more importance. See VARNISH.

This substance is principally to be met with on the sea coasts of Prussia. The river Giaretta in Sicily, formerly called Simetus, which takes its rise on the north side of Mount Etna, throws up near its mouth, great quantities of fine amber, some of which is more electric, and emits a stronger smell, than what is received from the Baltic.

Some pieces of this amber contain flies and other insects, curiously preserved. It is generally supposed to issue from the earth in a liquid state, at which time the insects that alight upon it, are caught, and by their struggle to get loose, soon work themselves into its substance; which hardening round them, they are for ever preserved in the greatest perfection.

AMBER-GREASE, AMBER-GRISE, or GREY AMBER, is a solid, opaque, generally ash coloured, fatty, inflammable substance, variegated like marble, remarkably light, rugged and uneven in its surface, and has a fragrant odour when heated. It does not effervesce with acids, melts freely over the fire into a kind of yellow rosin, and is hardly soluble in spirits of wine.

It is found on the sea coasts, or swimming on the sea, or in the abdomen of whales, in various shapes and sizes, weighing from half an ounce to upwards of one hundred pounds.

The ambergrease found in the abdomen of the whale, is not so hard or fragrant as that, which is found on the sea coast, but soon grows hard in the air, and acquires that particular odour, so agreeable to most people. It is known, that the cuttle fish is the constant food of the spermaceti whale; hence it is easy to account for the many beaks, or pieces of beaks, found in all ambergrease. Dr. Swediaur therefore defines ambergrease, to be the preternaturally hardened dung or fæces of the spermaceti whale, mixed with some indigestible relics of its food.

The colours of ambergrease vary; there is, first, the white ambergrease, which is scarce and of little value; as it seems, either not to be ripe, or mixed with some heterogeneous matter; then, the ash coloured or true ambergrease; afterwards the black ambergrease, which is inferior to the preceding sort, and frequently adulterated; lastly, the brown ambergrease, which has a particular, unpleasant smell. It looks mostly sleek or smooth, as if covered with a skin.

Ambergrease ought to be chosen in large pieces, of an agreeable odour, entirely grey on the outside, and grey with little black spots within. The purchaser should be extremely cautious, as this article is easily counterfeited with gums and other drugs.

Ambergrease is chiefly found in the Atlantic Ocean, on the sea coast of Brasil, off the East Indies, China, Japan, and the Molucca and West India Islands.

The use of ambergrease is now nearly confined to perfumery; it was formerly recommended in medicine by eminent physicians. In Asia and part of Africa it is also used as a spice in cookery.

AMMONIA. See ALKALIES.

AMPELITES, (cannel or candle coal,) a hard, opaque, fossil, inflammable substance, of a black colour. Though much inferior to jet, it is a very beautiful fossile, and for a body of so compact a structure, remarkably light. There is a large quarry of it near Alençon in France; it is also dug in many parts of England, of which the finest is in Lancashire and Cheshire. It makes a very brisk fire, flaming violently for a short time, and after that continuing red and glowing hot for a long while. It

is capable of a very high and elegant polish, and in the countries where it is produced, it is turned into a vast number of toys. It is likewise used for dyeing the hair black.

An alum ore found in Burgundy, and consisting of clay, pyrites, and bitumen, is also distinguished by this name. See COALS.

ANIMALS, DOMESTIC. Under this head we shall treat only of such animals as contribute, in an eminent degree, to supply the necessaries and conveniences of man; as the horse, sheep, &c. nor do we deem a very detailed account of these important, since their use and value are so generally known.

Of Horses.—Of all the animals in the brute creation, the horse doubtless claims pre-eminence, whether we consider him beautiful in form, swift in motion, or beneficial to the ease and comfort of mankind. It is not an easy matter to say to what country horses originally belonged; or, if we take into consideration their extensive utility, where they are produced in the greatest perfection.

Climate produces an astonishing effect on the size, strength, and elegance of this animal; yet food and attention to keeping and breeders, causes still greater. The horses of Canada are small and ill shaped, though strong and hardy; those of Pennsylvania, if we except strength, are, in general, the reverse; while those of Virginia and the Carolinas, are on a medium; though recently, by attending to breed, they have produced some that may vie, in point of beauty and swiftness, with all the rest of the world. But notwithstanding this great difference, there are, indisputably, good horses in every breed; and the chief object of the farmer is to select such as are best qualified for the uses to which they are to be appropriated. For the plough, both strength and agility are required; a dash or mixture of blood, therefore, is not disadvantageous.

It is not size that confers strength, the largest horse being often soonest worn out. A clever step, an easy movement, and a good temper, are qualities of the first importance to a working horse; and the possession of these is of more avail than big bones, long legs, and a lumpy carcase. To feed well is also a property of great value; and this property, as all judges know, depends much on the shape of the barrel, deepness of chest, strength of back, and size of the hips or hooks with which the animal is furnished. If straight in the back, and not over-short,—high in the ribs, and with hooks close and round,—the animal is generally hardy, capable of undergoing a great deal of fatigue, without lessening his appetite, or impairing his working powers; whereas horses that are sharp pointed, flat ribbed, hollow backed, and wide set in the hooks, are usually bad feeders, and soon done up when put to hard work: Hence it is matter of serious consideration, to breed only from the hardy and well proportioned tribes, these being supported at the least expense, and capable of undergoing, without injury, a degree of labour which would disable those of a different constitution.

The female brings forth one colt after a gestation of eleven months: none of the parent creatures should be under four years of age. Castration is commonly performed when the colt is twelve or eighteen months old; but the best practice is to delay that operation till the animal attains the age of two years, for they will then retain a greater degree of strength and spirit. If properly kept, they will live to the age of forty years; but mares do not breed after eighteen, and studs, or stallions, are useless at the age of twenty, so that they are fit only for the harness. Potatoes, carrots, furze, cabbage, &c. have been successfully tried as substitutes for oats, and the more expensive method of corn feeding. When, however, grain is used, the most economical way will be to boil and give it, with the liquor in a cool state, to the animal, by which simple means one half may be saved. Broken winded horses, when fed on carrots, soon recover.

A considerable reduction may also be made by cutting the hay into a kind of chaff, and mixing it with straw, or broken ears of corn, which arise in dressing grain; and also by soiling horses, as observed under the article Agriculture.

The management of horses, after having performed the labour of the day, is a matter of equal moment with their feeding; and as considerable expense has injudiciously been incurred by erecting elegant stables, we propose the following practice to the consideration of the rural economist. It consists simply in forming a small yard, provided with a shed that is open in front, and furnished with racks, as well as with a pump and cistern. A superstructure of this kind, if well littered, is in every respect preferable to a stable, and will preserve horses in better health, without requiring any other covering or dressing than is usually given when otherwise stabled. See FARRIERY.

Of the Ass.—The ass by naturalists is ranked as a species of the horse, and by

some, from his very great similitude in habits, while in a state of nature, and resemblance of external and internal parts, thought to be only a degeneracy of that noble animal. As, however, his history is foreign to the design of our work, we leave it for the investigation of the naturalist

This animal in his natural state is swift, formidable, bold, and fierce; but the moment he has lost his freedom, his disposition and habits are totally changed, and he becomes remarkable for meekness, patience, and tranquillity. He submits with firmness to chastisement, is temperate in his food, contenting himself with the refuse of other animals, but is extremely delicate in the choice of his drink, prefering the inconvenience of thirst to impure water. This animal is esteemed for his attachment; and, though treated with harshness and cruelty, is fond of his master, will trace him out by scent, and readily distinguishes him from other persons.

Of all animals the ass perhaps is capable of supporting the heaviest burthen in proportion to his size; and, on account of his slow and regular pace, is particularly useful in journeying over mountainous countries. He is regarded of little value in the United States, except in studs with the horse, which produces the mule, a mongrel animal, partaking both of the nature of a horse and an ass.

Of mules.—The mule is a very hardy animal, and will undergo changes in climate without being either unfitted for labour, or constitutionally injured.

On this account he is preferred in warm countries for the purposes either of draught or carriage, and in cold, though not so much used, he deserves to be more generally propagated, on account of his disposition, and stability, as also the little expence of keeping, his habits being very similar to those of the ass. These animals some times attain the height of 15 or 16 hands, carry heavy burthens, are sure footed and attain to a very great age.

Mares selected for the stud should be young, of a lively turn, small limbed, and with a head of moderate size; these with proper attention, will drop folds, which it will be necessary to house, in order to render them tractable, by being frequently handled. When three years old, they may be broken in; but it will not be adviseable to work them to any considerable extent, till they have attained the fourth year of their age. After which time, they will, if properly treated, continue in full vigour till they are past 30, and sometimes 40 years. It should however be remarked, that wheat and rye straw, disagree with their nature, and incapacitate them for hard labour. For the treatment of diseases incident to the Horse, Ass and Mule, see the article FARRIERY.

On Neat Cattle.—In treating on this valuable class of animals, we shall point out such vegetables as may be given them with advantage, state a few supplementary rules to be observed in their breeding, and conclude with some observations on the most common distempers to which they are liable.

I. WITH RESPECT TO FOOD.

The first object in the article of food, is wholesomeness: wild cattle feed entirely on the green vegetables, which they find throughout the year. Similar nutriment should therefore, if possible, be procured for tame cattle, in all seasons; but such food can be found only among those plants, which are either constantly green, or arrive at maturity in the winter. Of all vegetable productions, the most exuberant, for this purpose, appears to be the cabbage, with its numerous varieties: the disagreeable taste, which that plant is supposed to impart to milk, can be no reasonable objection to its use; as it may be obviated by boiling.

Turnips and carrots constitute the next article, and cannot be too forcibly recommended, especially as a winter food.

Almost every English book on farming extols the great benefit derived from feeding cattle during winter on turnips. In the United States the practice is not adopted of choice, and where an experiment has been made of this food, owing probably to some mismanagement, a favourable opinion of it has not been the consequence.

Potatoes furnish a supply, equally excellent and wholesome Horses are particularly fond of them. To these may be added, the plant, called whins, the utility of which has but lately become generally known They require, it is true, to be ground in a mill, before they are given to cattle, and do not materially ameliorate the ground, a circumstance considered as an objection to their culture; but, notwithstanding these apparent disadvantages, they produce an excellent and invigorating fodder, and constitute one of the cheapest articles of winter provision; as they continue green during the whole year, and will grow on the most indifferent soils.

In enumerating the various vegetables, which appear to be the most beneficial food for cattle, we have necessarily avoided entering into any particular details concerning their culture; but they will be noticed under the article GARDENING.

Two articles have lately been employed with considerable success in fattening cattle. The first is *wash*, or the refuse of grains remaining after distillation: this liquor is conveyed from the distillery in large carts, closely jointed and well covered, so as to prevent leaking. It is then discharged into vats or other vessels, and when these are about two-thirds full, a quantity of sweet hay, previously cut small, is immersed for two or three days, in order that the wash may imbibe the flavour of the hay, before it is used. In this state, the mixture is carried to the stalls, and poured into troughs, from which it is eagerly eaten by cattle. Some animals, however, shew at first an aversion to such food; in which case their hay should be frequently sprinkled with the wash; so that, by having the smell constantly before them, and seeing others eat with avidity the same preparation, it gradually becomes less nauseous, and is at length much relished. The cows and oxen thus fed, not only repay the expence of their keeping, by fattening speedily, but yield a large quantity of rich manure, which is more valuable than that from any other food.

An equally successful method of fattening cattle in general, and oxen in particular, consists in giving from half to a whole pint of molasses, twice in the day, to every *starving* animal, that has been exhausted by continual and severe labour, for a series of years. For this purpose, a gallon of oats, or any other grain, roughly ground, or the same proportion of potatoes, should be boiled in a sufficient quantity of water, to form a thick mash. It must be well stirred while on the fire, to prevent its burning, or adhering to the sides of the vessel; and, when it becomes cool, the mixture is formed into balls, each weighing about a pound. One half of these balls, after dipping them into the molasses in the morning (the remainder in the evening) is given to the cattle, which devour them with great eagerness, and speedily grow fat, by the addition of a little hay, or any green fodder that is not too succulent. Besides, one or two spoonfuls of salt are generally dissolved in the composition, which contributes to preserve the health of the animals; and in case ground corn cannot be procured, oil-cake, diluted with water, seasoned with a little salt, and moistened with the same quantity of molasses, may be advantageously substituted.

As the cattle of the United States have mostly originated from those of Great Britain, the subsequent observations on their breeding made on the latter will justly apply to both.

II. The breeding of cattle.

The English cattle are divided into several classes, or breeds, denominated from the different counties in which they are reared; as the Lincolnshire and Holderness, which are distinguished for their size; the Welsh and Norfolk breeds, which are as remarkable for their lean and wretched appearance, as the Lancashire and Herefordshire are for their beautiful and healthy look. Besides these, there are several others, as the Sussex, Devonshire, or Somersetshire, which, though fine cattle, do not attract that attention which is generally, and deservedly, paid to the Lancashire and Herefordshire breeds. The former of these is particularly celebrated for the improvements made by the late ingenious Mr. Bakewell, of whose mode of breeding we shall give a concise account.

There was a remarkable peculiarity in Mr. Bakewell's cattle; namely, their uncommon docility and meekness, which were so great, that a boy with a switch could, without any difficulty, conduct them from one part of his farm to another. This gentleness was the effect of management, and evinces the superiority of his mode of breeding. While we admire and acknowledge its excellence, we cannot but advert to the mischief which is frequently done by horned cattle, and doubtless arises from very contrary practices. Such injurious consequences, however, might be prevented by *tipping*, that is, by sawing off the points of the horns of cows, bulls, and oxen, and fixing on them small knobs of wood, about three inches in diameter; then boring a hole through the horn and wood, and clinching a nail on the opposite side. Although, by this precaution, the horns are in a manner despoiled of their beauty, yet, when compared with the advantages resulting from it, this trifling loss cannot be regretted.

Besides the rules we shall give under the head of Breeding, we shall in this place observe, that cattle may be much improved by *crossing the strain*, or breed; which is said to be attended with the most beneficial consequences. This practice, though ridiculed by some prejudiced farmers, is nevertheless sanctioned by the opinion and long experience of many successful breeders, and especially the late Mr. Bakewell; who has recommended the propagating from the old breed, only till a better could be procured.

In keeping live-stock on grain, as well as on grass-farms, their kinds, size, and number, in proportion to the means of

subsistence, deserve unremitted attention; as likewise the modes of keeping them, and saving their manure. It is asserted, that English cows require, in general, from one to two acres of pasture: this is mostly *made*, by sowing grass-seeds after the ground has produced crops for many years, being both ameliorated and exhausted under manurings and good tillage. Such land continues several years afterwards in grass, which is carefully cleared of brambles and strong weeds.

Some persons contend that pastures ought to be stocked very lightly; alledging, that although much of the produce is thus allowed to run to seed, which the beasts will not eat, and which of course is trodden under foot, and rotted by rain and thus wasted; yet experience they say, proves, that a greater profit will be thus derived from it, upon the whole, than by any other practice, on account of the superior thriving of the animals.

Others pretend on the contrary, that light stocking of grass land is a practice highly to be condemned; as it tends not only gradually to diminish its produce, but also to encourage the growth of coarse and unprofitable grasses, which greatly deteriorate the pastures; and that hard stocking of grass lands, especially those of a rich quality, is an indispensable requisite of good management.

These two opinions so diametrically opposite to each other, and which are equally maintained by sensible men, clearly proves the embarrassment to which they are subjected, in consequence of not having adverted to the circumstances stated above, and many other particulars that require still to be developed, as effecting the economical consumption of the produce of grass-lands.

A third party, who approach perhaps nearer to the truth than either of the above, advise, that mixed stock should be always kept upon the same field: and were the consumption of the foul grass produced by the dung of the animals, the only article to be adverted to, it might be, doubtless, so managed as to correct this evil: but there are so many other circumstances to be adverted to, that it is not easy, by this means, to get them all remedied.

In every field, a variety of plants spontaneously spring up, some of which are disrelished by one class of animals, while they are eaten by some others; and some of which plants, though eaten readily by some animals at a particular period of their growth, are rejected by them entirely at another age. Thus it becomes necessary, not only to have a vast variety of animals in the same pasture; but also a very particular attention is required to augment or to diminish the proportion of some of these classes of animals, at particular seasons of the year, otherwise some part of the produce will be allowed to run to waste, unless it be hard stocked to such a degree as to retard their thriving.

But if a great variety of animals be allowed to go at large in the same pasture, they are never suffered to feed with that tranquillity which is necessary to insure thriving in the highest degree. One class of these wishes to feed, or to play, while the others would incline to rest. They thus mutually disturb and tease each other: and this inconvenience is greatly augmented, if penning of any sort be attempted. From these considerations, the practice of intermixing various kinds of stock very much together, is found to be productive of evils, in many cases, greater than those which result from the waste of food this practice was intended to prevent. And though there is no doubt that by hard stocking the grass will be kept shorter, and consequently will be more palatable in general to the animals which eat it, than if it were allowed to run to a great length, and that thus even unpleasing patches may be consumed; yet as animals, which are to be fattened, must have not only sweet food, but an abundant bite at all times, to bring them forward in a kindly manner, it seems to be nearly impossible to obtain both these advantages together in the practice of pasturage.

Under every point of view, that this question can be considered, we are forced to conclude, that the practice of cutting of grass, and consuming it green, in all cases where the ground is in a state that can admit of it, when compared with that of pasturage appears to be so greatly economical, that the particulars under which that mode of management can be practised, and the peculiarities affecting it, deserve to be much more minutely investigated, than they ever yet have been.

In confirmation of the justness of this conclusion, it is now universally admitted as a fact, that a crop of red clover, when cut and consumed in the house green, in all cases, will go at least twice as far, when cut, as when pastured upon: some go as high as to say it will go *four times* as far. As every person, who has tried the experiment, agrees, that the saving, by cutting this crop, is very great, that practice has of late years be-

gun to prevail very much; though reason has not yet been able to stem the torrent of ancient prejudice, so as to render it entirely universal.

But the cutting of other grass grounds, and consuming their produce green, seems not to have been deemed even practicable, and has not of course been ever thought of being experimentally tried.

The field should begin to be cut when the longest piles of grass on it have attained the height of two inches at most, and proceed regularly day by day, cutting as fast as the beasts consume it, so as to go over the whole in three or four weeks as the weather is warm or cold; when that which was first cut will be ready to be cut a second time, and so on. The grass should be carried off in a light sparred or wicker cart, drawn by one small horse; this cart to move upon three broad low wheels, placed two on one axis and one on another, below the body of the cart, so as to act as a roller when going over the ground: a cart or rather barrow, of this construction, has been found a most convenient implement. In this manner the work will proceed regularly, and without trouble throughout the whole season: the beasts should be regularly fed; getting only a small quantity at a time, but frequently, and fresh; giving them sweet water when necessary, and as much grass as they will eat, allowing them proper time for rest. Nothing should be left in their stalls, at these times, to be breathed upon, and thus rendered disgustful to them; and if the house be so constructed as that the beasts can be easily kept cool to a proper degree, quiet and clean, they will thrive abundantly.

Grass lands, if constantly cut, are not deteriorated.—What the changes would be, both in regard to the quantity and the nature of the produce from the same field, if annually cut, and the produce carried off, as above mentioned, or if consumed by suffering beasts to pasture upon it, cannot at present be told with certainty; but there are not wanting facts that enable us to have some idea of the probable result.

But surely stalls may be constructed under trees, so as effectually to secure the animals from the flies, and at the same time enable them to enjoy air. An attention to both these particulars is indispensable to the preservation of their health, and the speedy fattening of the animals.

The grass must be cut in the morning for the evening food, and in the afternoon for the morning mess; the afternoon crop must be carried to the barn, and spread to exhale its superfluous moisture; and in rainy weather, both crops must be taken off the ground. Attention must however be paid to the due proportion to be cut.

Upland blue grass is particularly proper for soiling, because it inclines to grow rank and hard, and to bind the soil, and therefore will bear close and frequent mowing. But whether the practice of soiling or pasturing be followed, it is essential that the grass be *occasionally changed.* All animals thrive better from a change of food.

In cases, however, where it is impossible to *soil*, the next best method is to make a proper division of the land, and to proportion the number of head to the quantity of acres. Cattle should be changed from a field whenever the grass is eaten short: otherwise they will fall in flesh, and additional time and grass will be required to bring them to their former standing. It is only by regular full feeding, that cattle will soon be brought to look well, and to be fit for market.

Where a small number of cattle are fed, and it is necessary to turn them into a clover field in the close of the day, a man should watch and turn them out the moment they are satisfied, otherwise they will lie down, or stroll about, and by blowing on the grass, will cause great waste.

Dr. Mease observes, that cattle fed in the meadows south of Philadelphia, are generally kept one year before they are sold—They are *pastured* one summer, and then stall fed upon hay, and four quarts of meal of Indian corn, and three quarts of chopped potatoes three times a day. In the spring and early in the summer, they are sold. In some cases they are fed on hay alone, in which case they require two tons per head; but having short feed as above, each requires but one ton. Hay composed of white clover and timothy fattens quickest. One grazier thinks that the second crop of blue grass and clover is best to make hay; but a farming friend thinks that this mixture is not nourishing, though cattle will eat more of it. In stall feeding cattle, it is a common practice to give a certain mess every day without regard to any circumstance, but an experienced feeder deems this practice absurd, and justly observes that a bullock will eat with a much keener appetite on a clear cold day, than in warm

damp weather; his mess ought to be proportioned accordingly. By giving the same quantity every day, the animal may be induced to over-eat itself, and many days may elapse before he will recover his appetite. By this delay he may fall away, and time will be required to bring him to his former good flesh. The waste hay, or that made from grass mowed after the cattle, is used commonly to feed the stock when the winter sets in; the best hay being reserved for the spring before the beasts are turned out to grass. A handful of salt is broad cast over every load as packed in the loft, and so grateful is this condiment to them, that they have been observed to prefer poor hay salted, to good hay unsalted.

The economical Flemish and German practice of boiling the potatoes, corn, &c. is not followed. But there can be no doubt that a portion of liquid food given every day, would have an excellent effect in producing an open state of the bowels, in loosening and softening the hide, and keep the animals in better plight, than by confining them to dry food. Beans, mashed potatoes, mashed turnips, rye, Indian corn and oats, coarsely broken, should be boiled with a large proportion of water, and given warm: salt may be added when the mess is poured into the troughs. Corn blades and corn stalks may be also boiled with double advantage instead of giving them dry. The Germans in Lancaster county, now chop their corn cobs by means of mills, and with great benefit. If boiled, they would still go further, for their juices having been extracted by the water, would nourish, while the solid substance would stimulate by its quantity, and thus combine the characters of a strong food.

A boiler properly constructed, so as to save the heat, would render the expense of its erection a trifle; and this trifle would be more than balanced by the greater quantity of nourishment afforded by the process.

Cattle fed on a mess of sour food, prepared by fermenting rye flour and water, and then diluted with water, and thickened with hay cut small, are said to fatten quickly. It is known that hogs derive more benefit from sour milk and swill than when fresh, and it is highly probable that good effects may be derived from acid food for horses, but it can only be considered as preparatory to the essential article *Indian corn* without which neither steer, or hog will acquire that firmness in muscle and fat which are so deservedly admired.

Much, however, depends in the fattening of cattle, on their "*thriving disposition:* singular as it may appear to many of our readers, the tendency of animals to become fat, is not a little promoted by what is called *sweating them;* a practice which has been attended with uncommon success This has been particularly experienced by the ingenious Mr. Moody, who asserts, that the hotter cattle are kept, the better they will fatten. He therefore shuts them up in an ox-house, and for some time admits no air to enter through the holes of the doors. The breath of so many beasts, and the heat of their bodies, soon make them sweat exceedingly, and when this is at its highest point, they most speedily fatten. After sweating two weeks all the hair falls off, a fresh coat appears, and they sweat no more: but those beasts which do not sensibly perspire, seldom grow fat.

Linseed oil-cake remarkably contributes to the fattening of cattle, and renders their dung much richer than any other vegetable aliment; but, as this article is advancing in price, and difficult to be procured, it has lately been superseded by linseed-jelly, which is incomparably superior, and when given with hay or meal, makes an excellent mixture for stall-fattening. It is prepared as follows: To seven parts of water put one of linseed, for 48 hours; then boil it gently for two hours, stirring the mass continually, to prevent it from burning. It should afterwards be cooled in tubs, and mixed with meal, bran, or cut chaff. Mr. Moody gave two quarts of this jelly every day to each large bullock, which amounts to little more than one quart of seed in four days, and is a great saving in the article of food.

Flaxseed jelly would no doubt be more agreeable to the animals, less liable to surfeit from an accidental over proportion, and less liable to affect the meal with a peculiar taste, than either oil or cake, and therefore deserves to be tried.

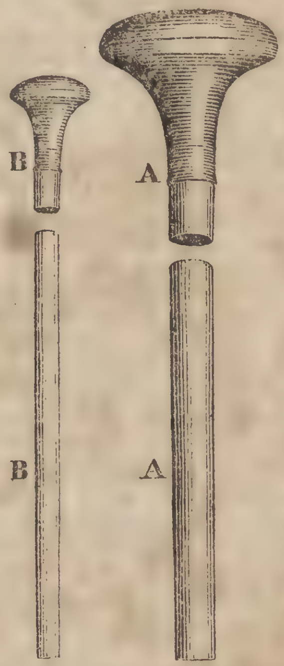
To each head may be given, about half a gallon of jelly daily, mixed with meal and cut straw. But this food ought to be changed about one month, before the animal is killed, to prevent the possibility of the flavour of the oil, cake, or jelly, remaining in the flesh.

III. The Diseases of Cattle.

No distemper is perhaps more common among these useful animals, than that of being swoln, that is, *blown* or *hoven*, as it is termed by farmers. It arises either from their being exposed to damp situations, or from eating too greedily of any succulent

food, such as turnips, clover, particularly *red clover*, which is a dangerous food for horned cattle; for, when wetted by dew or rain, it may prove a destructive poison. For this fatal malady, various remedies have been tried, with more or less success, of which we shall select the most effectual and expeditious. The general practice is, to make an incision with a penknife in the body of the affected animal, [under the short ribs, and a tube of ivory, bone, or smoothed elder put in :] in order to give vent to the confined air: the wound is then covered with a common or adhesive plaster, to prevent external cold from penetrating it; and thus the danger, in general, is speedily removed. But, where it is practicable, it surely behoves us to employ more gentle remedies for the alleviation of this disorder: we, therefore, extract with satisfaction, the following recipe from the *Annals of Agriculture;* where it is announced as a specific for hoven cattle, even in the most desperate cases; effecting a cure within the short space of half an hour.—Take three quarters of a pint of olive oil; one pint of melted butter, or hog's lard; give this mixture by means of a horn or bottle; and if it does not produce a favourable change in a quarter of an hour, repeat the same quantity, and walk the animal gently about. For sheep attacked with this malady, the dose is, from a wine glass and a half to two glasses. Besides these remedies, instruments have been invented for the purpose of relieving blown cattle; two of these contrivances we shall describe, as being particularly distinguished for the ingenuity of their construction, and the speedy relief they afford. The first is a flexible tube, invented by the celebrated Dr. Munro, Professor of Anatotomy at Edinburg: it consists of iron wire, about one sixteenth of an inch in diameter, twisted round a rod three eighths of an inch in diameter, and made of polished iron, in order to give it a cylindrical form; the wire, after being taken off the rod, should be covered with smooth leather. To the end of the tube, which is intended to be passed into the stomach, a brass pipe two inches long, of the same size, or rather larger than the tube, is to be firmly connected; and to prevent the tube from bending too much within the mouth, or gullet, an iron wire, one eighth of an inch in diameter, and of the same length as the tube, is put within it, but afterwards withdrawn, when the tube has entered the stomach.—As Dr. Munro has ascertained that the distance from the fore-teeth to the bottom of the first stomach of a large ox, is about six feet, the tube ought, therefore, to be at least two yards long, that it may operate effectually in the largest oxen. When the instrument has been introduced into the stomach, it may remain there for any length of time, as it does not obstruct the respiration of the animal: the greater part of the condensed air will be speedily discharged through the tube; and, should any ardent spirits, or other liquor calculated to check the fermentation, be deemed necessary, it may be safely injected through this pipe. In short, the flexible tube here described, has been found of infinite service in saving the lives of cattle, and especially of sheep, when subject to similar disorders, or any other swelling peculiar to these creatures.

Another *Instrument for relieving hoven cattle and sheep*, is that contrived by Mr. Richard Eager, of Graffham farm, near Guildford. Its peculiar simplicity, and great utility, have induced us to subjoin the following representation.



A, A, is the knob of wood, and part of the cane to which it is fastened, of a proper size for oxen: the length of the cane should be at least six feet.

B, B, is the knob of wood and part of the cane, calculated for sheep, and the

length of which ought to be about three feet.

When any beast is blown or hoven, Mr. Eager directs a person to lay hold of it by the nostril, and one horn, while an assistant steadily holds its tongue with one hand, and pushes the cane down its throat with the other. Care, however, should be taken, not to let the animal get the knob of the cane between his grinders, and also to thrust it down far enough; because its whole length will do no injury. As there will be found an obstacle at the entrance of the paunch, the cane must be pushed with additional force; and, as soon as a smell is observed to proceed from that place, and the animal's body sinks, the cure is performed, and Nature will complete the rest.

Mr. Eager justly attributes this disorder to the superabundance of air introduced into the stomach, by eating too large quantities of succulent food, which occasions a greater than natural portion of wind to ascend from the paunch of the beast. This forces the broad leaves before the passage, at the entrance of the stomach; and these leaves prevent the wind from passing upwards in its regular course. Thus the paunch immediately begins to swell; the heat of the body rarefies the air, so rapidly as to impede the circulation of the blood, and the animal, whether bullock or sheep, unless instantaneous relief be procured, expires in half an hour.

The Rev. Mr. E. Parsons of E. Haddam, Connecticut, describes a disease in the *Medical Repository*, *New-York*, vol. 1. which has been very destructive to horned cattle in Connecticut for ten years past. It is chiefly confined to cattle under three years—Cows are sometimes attacked, but oxen rarely. It has been most fatal to calves in autumn and to yearlings in May and June. The largest and highest fleshed are most liable to the disease.

The vulgar name for the disease is "*The mortification.*" The symptoms are, unwillingness to move, a soft swelling in the leg, shoulder, flank, side, but oftener in the back and region of the kidneys. In the course of six, twelve, or twenty-four hours, life terminates with little expression of pain. The stink before death is intolerable. Upon skinning, the swollen spot is found to contain a jelly and black blood.

The cause of the disease is supposed to be too much fulness, or *plethora*, as it proves destructive to cattle after a change of pasture or fodder, from bad to good. Many calves have died after feeding in the fields of grain.

The remedies are chiefly of the preventive kind, such as bleeding, or a change of pasture of a better quality, and care not to permit a sudden change, from bare to full bite. One person bled copiously in the neck, gave the animal his own blood to drink, which purged; and then made an incision in the swollen spot, took out the jelly and gore, and filled the cavity with rum and salt; after which the recovery was gradual. Three head of cattle thus treated, recovered: on all the rest this treatment had no effect, either good or bad.

A disease which originally appeared in a drove from North Carolina, in the autumn of 1796, spread devastation throughout the country among the cattle as it passed, near Columbia, on the Susquehannah, where the drove remained *one night* in a ploughed field. The stock of the farm were seized in a few days afterwards, and many perished. At the same time the beasts in the drove appeared *perfectly well.* The disease was traced down to Derby, 8 miles S. W. of Philadelphia, where great havoc was occasioned by it. The symptoms were first, disinclination to food, inability to stand, tumbling, laborious breathing, and deep groaning: bloody urine was sometimes discharged. Costiveness, in general, was a symptom. The blood was dissolved when drawn. No remedy was found effectual.

The circumstance attending the above-mentioned disease, suggests the propriety of keeping drove cattle separate from an old stock for some time, and of permitting the latter to mix with the former by degrees, in order to see whether a disease appears.

The little attention that has hitherto been paid to the diseases of cattle in the United States, is a matter of very serious concern. It frequently happens that an epidemic rages among horned cattle with great violence, and no more information is communicated respecting it, than what is contained in a newspaper paragraph, though the country abounds with men of education, fully capable of recording a good account of the disease. Such negligence is highly reprehensible, and by continuing it, we shall always remain stationary in our knowledge of the diseases of cattle. The symptoms ought to be described, whether the complaint may or may not be cured and the various remedies stated, in order to direct the mode of cure, or prevent the loss of time on future occasions. Many thousands of dollars were lost by the fatal disease mentioned above, and noticed first among the North Carolina drove, and yet no other account of it is to be found, except the im-

perfect one here given. In Europe, the diseases of cattle are deemed worthy of particular attention by men of science, and professorships are endowed in many universities, for the express purpose of having the physical economy of all domestic animals properly examined. The advantages of these establishments are often perceived, and no time ought to be lost in following the example in the various colleges in the United States. It is well known that England was indebted to a physician (Dr. Ledyard) for the stoppage of the ravages of a wide spreading epidemic which raged among the horned cattle between 1750 and 1760.

Cattle are also sometimes affected by diseases of the hoof; in consequence of feeding upon hay made of the bog meadow grass. Such a disease was seen in Blooming Grove, near Gray Court, New-York, in the winter succeeding the dry summer of 1793. Many beasts lost their hoofs entirely.

A similar complaint prevails among cattle from feeding upon the natural grass which comes upon meadows made by banking out the river Delaware, and which are not duly watered. The ends of the blades of the grass become tipped with a black powder similar to rust on grain. Cattle do not relish the grass, and will not eat it unless forced by necessity. Care must therefore be taken to water such meadows at proper seasons.

There are various other distempers, to which the farmer's live-stock are frequently subject. With respect to the nature and cure of which, we refer such of our readers, as may wish for more minute information, on the subject of cattle, to Mr. Culley's *Observations on Live-Stock*, a small work that was published a few years since, and is believed to possess considerable merit: also Mr. Topham's *New and compendious System on several Diseases incident to Cattle;* a work containing some valuable hints, and of which a new edition was lately published.

Before we conclude this interesting article of national importance, we shall add a few general remarks, tending chiefly to preserve the health, and improve the physical properties of cattle. It is admitted, by all enlightened breeders, that *cleanliness* is one of the most essential requisites to the prosperity of those animals; and we may venture to add that, in this respect, a degree of attention ought to be paid, little inferior to that bestowed on the human frame. Hence, frequent washing, especially after hard labour; friction with proper brushes, and curry-combs, gentle walking after a fatiguing journey; and the immediate removal of litter, both from the stalls, and farm-yards, should not be neglected.

Cattle should be supplied with a sufficient quantity of common salt; and for the reasons already stated, we are of opinion, that ALL kinds of cattle, especially *sheep*, would be much benefited by the continual use of this simple and natural spice, which eminently conduces to the digestion of succulent vegetables, and is almost a specific for preventing the effects of flatulence. *Salt* cannot be given in excess: it is affirmed, that it *enables the farmer to increase his live-stock*; *as it augments the nourishment of the food eaten, in proportion to the quantity of saline matter.* It is also said greatly to improve the wool in quality, as well as quantity. Hence it ought to be freely given to sheep, and cattle of every description: but, to imitate Nature, it should be previously dissolved, and then mixed with a pure, fine clay, in a mass, which is to be placed under shelter, so that the animals may lap it at pleasure: such is the process which the unprejudiced grazier will be disposed to adopt. Mr. Bordley, relates a fact worthy attention. About sixty years ago, he learnt, from a country farrier, that, "once or twice a week, giving salt to horses effectually secures them against *botts*;"—ever since that period, he has experienced the good effects of this management; and adds that, during twenty years' residence on his farm, at Wye, in Maryland, he always kept upwards of fifty horses on the banks of a river, containing *salt-water*, and never met with a single instance of that disease.

Of Sheep.—Sheep are a genus of quadrupeds consisting, according to Linnæus, of *three* species; though later naturalists admit only *one*, and consider the others as varieties. The principal is the *aries*, or common ram and ewe. Their bodies are covered with long, whitish, slender interwoven hair, which is termed *wool;* and, when shorn, the *fleece.*

In a wild state, the sheep is lively, robust, and able to support fatigue; but, when domesticated; and fed in pastures, it becomes timid, and resorts in the hour of danger to the shepherd and his dog, for protection.

Ewes generally breed at the age of eighteen months; though the most experienced breeders never suffer them to increase their species, till they are at least two years old; and, as these animals are of considerable value, great attention is bestowed on their management at this period.

The first object therefore is, whether the breeder has sufficient grass to maintain the ewes and their lambs in the spring; or, whether he has a stock of turnips adequate to their support, till the pasture affords them food. The next consideration is the *choice* of ewes, in which case the same characteristic marks should be observed as in the choice of the *ram.* another circumstance of great importance, is that of attending to the *breed;* because no certain degree of excellency can be attained in any species of cattle, unless the female possess an equal degree of *blood* with the male.

Ewes bring forth one, two, and sometimes three lambs, after a gestation of twenty weeks; so that the most advantageous period may, in general, be easily ascertained. The best time of yeaning is the month of April; unless the owner have very forward turnips or grass, or the animals be *field-sheep;* and in the course of sixteen or eighteen weeks after the lambs are dropped, they may be taken from their dams. They are, however, very tender, and require the greatest care, especially during stormy weather. They are subject to few disorders. When they are sick, the drinking of mares' or goats' milk diluted with warm water, will greatly tend to preserve them; and as many, when yeaned, are apparently dead, it is advisable to blow into their mouth and nostrils, by which simple means numbers have been immediately restored. The most fatal distemper, however, with which lambs are afflicted, is the blood or red water. The disordered animals are, in general, seized with lameness, swelling of the joints, which is attended with violent inflammation over all parts of the body, and, if neglected, proves fatal in the course of twenty-four hours.

The red water is occasioned by too great a quantity of undigested food remaining on the stomach; as soon, therefore, as the lambs are attacked, bleed them, and administer emollient clysters occasionally, till an evacuation takes place. Two or three grains of tartar emetic, or as many ounces of sweet oil, are now to be given, and the bleeding repeated, if the animal does not appear to recover. This treatment is to be continued four or five days, during which the diseased creature should be fed with milk.

If, however, the males are designed for wethers, the necessary operation should be performed early, except when they are unusually weak; in which case it will be advisable to defer it, till they acquire sufficient strength: on weaning the lambs, their dams may be milked two or three times, in order to relieve their udders.

The most proper time for *shearing* sheep, is towards the middle of May, or at the farthest, about midsummer; though some breeders defer it till the middle of July: because they suppose that an additional half-pound weight in every fleece may be obtained, by the increased perspiration of the animal. An early sheering, however, is preferable; for the new wool will thus not only gain time to *get a-head,* but the animals are also secured from the attacks of the fly; whereas, by delaying the operation, they become a more easy prey to the maggot; in consequence of which, they pine away, and lose all their flesh. But, previously to shearing, the sheep ought to be washed, and kept for a few days in a clean yard, or in a dry pasture, whence they should be taken out separately; after they are shorn, it has been recommended to wash them with sea-water; or, where this cannot be procured, with a brine made of common salt and soft water; as such practice is calculated to prevent the various diseases, incident to these useful creatures.

Farther, it is usual to mark sheep when divested of their wool, with some colouring matter; in order to distinguish those belonging to different proprietors. The fossil known under the name of *reddle,* or *ruddle,* is generally employed for this purpose. Dr. Lewis, with the same intention, directs finely levigated charcoal, (or preferably *lamp-black,*) to be mixed with tallow, over a moderate fire, in a proportion sufficient to produce a deep black colour, and a proper consistence. To render this compound more durable, he observes, that one-fourth, sixth, or eighth part of *tar* may be melted together with the tallow; the whole of which, however, will be readily discharged from the wool, by washing it in soap water.

With respect to the feeding and fattening of sheep, the nourishment derived from turnips experience has evinced to be one of the most lucrative methods. Some farmers turn the sheep into a field promiscuously, suffering them to eat the roots at pleasure; but this practice is by no means economical. Others divide the land by hurdles, and inclose the animals in such a space as they are able to clear in one day; advancing progressively till all the turnips are consumed. Another mode consists in digging or pulling up a sufficient quantity of turnips, and then admitting the sheep into the inclosure. The most advantageous expedient, therefore, is that of

exposing these roots on the surface of the soil, and removing the sheep to a fresh place every day; and if a small quantity of pease (not exceeding two or three bushels per *diem* for 150 wethers) be allowed, the animals will eat both turnips and their leaves, from which they will obtain additional nutriment, and grow uncommonly fat. Farther, this management will be attended with beneficial effects on the soil; so that a piece of land, contiguous to the turnip-field, may be manured without the expense of conveying dung by carriage. And, as the ground on which turnips are generally cultivated, is too moist for sheep in autumn or winter, it would not only be *poached* by the opposite old method, but the roots would also be trodden in; and, from their great moisture, the animals become liable to be seized with the rot.

Sheep are subject to various diseases, in common with other cattle, such as that of being *hoven*, &c.; but there are several disorders peculiar to the former; and which, it will be useful to state, together with the most approved remedies: namely,

1. The *Fly-struck*, a disorder that is occasioned by a fly that settles and deposits its eggs on them, and very materially injures the quality of the fleece. In order to remove this malady, cut off the wool as far as it is affected, then pour a few drops of the following mixture in a circle round the maggots, produced from the flies, to prevent their escape. Dissolve half an ounce of corrosive sublimate in two quarts of rain water, to which add one fourth of a pint of spirits of turpentine. After the circle has been made, as above directed, the shepherd ought to drop a little among the maggots, which being rubbed with the finger, will be immediately destroyed. Another remedy, after clipping the wool, is to rub the parts infected with finely powdered lime, or wood ashes, and afterwards to anoint them with curriers' oil, which will heal the wounds and secure the animals from being stricken again.

2. The *Rubs* or *Rubbers*, may be known by the restlessness of the animals, which rub themselves in every attitude; their skins being perfectly clean, without any trace or scab: when dead, their flesh assumes a greenish cast, but does not possess a bad taste. Sheep fed in fine meadows are more liable to be thus affected, than such as are pastured on poor soils: the disease generally terminates at the end of three or four months. No cause has yet been assigned for the *Rubs;* the malady having hitherto appeared chiefly in the county of Norfolk. Mr. Young, however, informs us, that it originates from a whitish-yellow worm which settles in the brain; being about an inch and a half in length, and of the thickness of a common goose-quill. He observes, that, at present, there is no prospect of cure; but, if the generation of this insect could be discovered, the disorder may possibly be prevented.

3. The *Rot* is a very fatal disorder, which exclusively affects sheep. It is known by the dullness of the animal's eyes; the livid hue of the gums; foulness of the teeth; the ill scent of the breath; and the facility with which the wool, and, in the last stage, the horns may be pulled out, or separated from their roots.

Various causes have been assigned for the origin of this malady; but, as the general *predisposing* causes obviously consist in too moist food, or damp and wet situations, it follows that *moisture* may be considered as the principal source of the rot.

The remedies contrived for the prevention and cure of this distemper, are as various as the conjectures respecting its origin. Miller recommends parsley, as being eminently serviceable. Mr. Price recommends every farmer to remove his sheep, in wet and warm seasons, from such lands as are liable to occasion the rot; but, if this be impracticable, he prescribes a spoonful of common salt for each, together with a similar quantity of flour, in a pint of water, once or twice in the week, by way of preventive: and, if the disorder be in an incipient state, a similar dose administered four or five successive mornings, will, in his opinion, probably effect a cure; as the addition of the flour and water not only abates the pungency of the salt, but also disposes it to mix more gradually, though at the same time more efficaciously, with the chyle. Dr. Darwin, however, thinks the salt would be more serviceable, if it were combined into a ball with about sixty grains of iron filings, by means of flour, and introduced into the sheep's throat every morning, for one week.

The following remedy we state on the authority of the *Gentleman's Magazine*, vol. 36, for 1766:—Put a handful of rue into a pail of water, over-night; and, in the morning, add such a proportion of salt as will make a brine sufficiently strong to support an egg. Half a pint of this liquor must be swallowed by each sheep, three times, in the course of six days; that is, every forty-eight hours one dose.

In October, 1794, a patent was granted to Mr. Thomas Fleet, for a medicine

which is affirmed to prevent the rot in sheep, and also to check the farther progress of the disease in animals already infected; so as to render them capable of being fattened on the same herbage which produced the distemper. His *restorative* consists of turpentine, Armenian bole, turmeric, mercury, salt, sulphur, opium, alkanet root, bark, camphor, antimony, and distilled water. These ingredients are to be prepared according to chemical, and compounded according to medical art. Although the patentee has not deemed proper to inform the public of the proportions employed in compounding these multifarious ingredients, yet it deserves to be remarked, that in such a mass of different drugs, the principal effects will be produced by a *few*, while the others are added only with a view to disguise those, which are more efficacious. Hence we believe, that a few grains of muriated quicksilver, combined with camphor, and opium, if judiciously administered, would answer a similar purpose.

4. The *Scab*, or *Shab*, is attended with an intense itching and scabby eruptions on the skin, occasioned by an impure state of the blood; and being most prevalent in wet land, or during rainy seasons. As this disease is generally believed to be infectious, the animals under its influence ought to be carefully separated from the flock.

Various remedies have been devised for the cure of the scab: the most common is that of washing the part with a decoction of strong tobacco in water, to which is added a small portion of oil of turpentine. Another application consists in rubbing the sheep with tobacco-water, sulphur, and alum boiled together, if the eruption extend over the whole animal; but, if it be only *partial*, a mixture of tar and grease will be sufficient.

In an *inveterate scab*, the anonymous author of the *Farmer's Calender* recommends sulphur and bay salt, or purging salts, to be given internally, and the distempered beast to be dressed with a strong mercurial ointment mixed with *Mel Ægyptiacum*; or to be washed with a lather of black soap, or sublimate-water, lime-water, and oil of turpentine. The treatment, stated under the head *Fly-struck*, is likewise said to be efficacious in this malady.

The following preparation is stated in the *Cardiganshire Landlord's Advice to his Tenants*, as being effectual in removing the scab, namely: Take one pound of tobacco, six quarts of beef brine, six pennyworths (or about an ounce) of white arsenic, and one pint of oil of turpentine. These ingredients are to be mixed with a small portion of tar, and boiled: previously to the use of this liniment, it will be necessary to *break* every scab, and the sheep must be well rubbed, so that the liquid may thoroughly penetrate.

In some places, the animals affected with the *scab*, are usually washed with *human urine:* but such treatment is pernicious; for, if the disorder be only partial, it will in the course of two or three days spread as far as the sheep may have been wetted.

There are various other expedients suggested for the cure of this eruption; but we believe the following to be one of the most efficacious: it was communicated by sir Joseph Banks to the Society for the Encouragement of Arts, &c. in 1789. He directs of pure quicksilver one pound; of Venice turpentine and common oil of turpentine half a pound each; and of hog's lard four pounds, to be triturated in a mortar, till the mercury be completely incorporated with the ingredients.

The method of using this ointment is as follows: The head of the sheep must first be rubbed; after which a furrow is to be drawn with the finger, from the region between the ears, along the back to the point of the tail, so as to divide the wool, till the skin be exposed to the touch. Next, the finger, being slightly dipped in the preparation, should be drawn along the skin. Similar lines should farther be opened down the shoulders and thighs, as far as the wool extends; and, if the animal be considerably infected, two other furrows are directed to be traced, parallel to that on the back, and one should likewise be drawn downwards, on each side between the fore and hind legs.

After this application, the sheep may be turned among the flock, without any danger of the infection being communicated; because, in a few days, the blotches will dry up; the itching will cease; and the animals be completely cured; nor have any instances occurred, in which such unction has been in the least injurious. Sir Joseph Banks, however observes, that the external remedy ought not to be delayed to a later period than Michaelmas.

5. The *Dunt* is occasioned by a vesicular collection of water in the head; and for which no cure has hitherto been devised.

6. The *Fly* or *Maggot*, is an insect that breeds in the skin of sheep. If the animal be attacked before shearing, it becomes sickly and indisposed; its wool, not yielding a sufficient quantity of *yolk*, af-

fords a warm nest for the reception of the eggs, which are speedily hatched. The maggots immediately feed on the flesh of the sheep; and, if they be not timely destroyed by the application of tar, the vermin will multiply so rapidly, as to destroy the animal in a short time.

7. *Giddiness* is conjectured to proceed from a worm, which insinuates itself under the horns, and causes the sheep to stagger, or reel: it may be cured by perforating those parts. Such distemper is also said to be induced by weakness, in consequence of poor *keeping:* hence, relief may be afforded by removing the animal to better pasture, and allowing it a sufficiency of dry nourishing food.

8. *Hunger-rot* generally arises from poverty of winter provender, and may be ascertained by the leanness of the animals. The proper cure is an immediate change of fodder.

9. The *Tick* is a small, flat, brownish insect, that infests sheep; and, if it be not speedily destroyed, is very detrimental both to the flesh and wool: it has six legs, and a flat proboscis with three notches on each side; by means of which it insinuates itself into the *pelt* or skin. Soon after the insect has thus settled, its legs drop off, and a scab is formed on the surface; from which a small portion of ichorous matter is discharged. The scabby crust increases with the growth of the tick; which, when arrived at its full size, nearly resembles that of a middling horse-bean; and other insects are generated, to the great injury of the flock. In order to remove these troublesome vermin, it has been recommended to mix an ounce of corrosive sublimate, a quarter of a pound of bay-salt, and one ounce of cream of tartar (the last two articles being previously pulverized and sifted), with two quarts of soft water. The wool must be separated, and the diseased spots washed with this liniment two or three times, or oftener, if it be found necessary; till the insects be effectually destroyed.

The Rev. Dr. Heters of London, who formerly resided in the United States, patriotically published the following remedy, for ticks, in the news-papers, last year, for the benefit of the American farmer. The remedy is to be applied in October.

"*The mode of making the unction to destroy ticks on Sheep, viz.*—Take one gallon of tar, put it into an iron kettle, over a slow fire, until rendered liquid; then having eight pounds of salt butter melted in another kettle, pour it gently into the tar-kettle, stirring them well together, leaving the salt of the butter at the bottom, then increase the fire, and make the tar and butter boil together, stirring them all the time; after boiling, pour it into any dish to cool. The next morning the unction will be of a proper thickness, and fit for use.

The next day after washing the sheep, they are sheared, and no ticks will appear until the wool becomes long in October, and incommoded by summer damps and ill health which are removed by a new salving.

To salve a sheep; the shepherd parts the wool with his fingers on the backbone from the head to the end of the tail, then with two fingers rubs the unction plentifully on the skin or flesh; so that the ointment may spread by heat of the body, two or three inches down each side from the ridge bone.

The shepherd then parts the wool as before, two or three inches from the ridge bone, and rubs the unction as before in such abundance, as it will spread two or three inches downwards, then continues the same method all around the sheep. The shepherd will salve a score of sheep in one day; and the unction will kill and destroy all ticks, cure and prevent the scab, soften and supple the skin, promote the growth and increase the quantity of wool. The sheep being freed of ticks will be quiet, comfortable and healthy, whether fat or lean, and whether with a large fleece on, or shorn. The expence and trouble is too small to be mentioned, when compared to the profit, advantage, and humanity of the action."

10. The *White Scour* is an uncommon looseness, occasioned by feeding sheep on putrescent vegetables; and particularly on the shells of turnips, which have been suffered to lie on the ground for some time, after the animals have eaten or scooped out the substance of the root. As soon as this malady appears, it has been directed to pulverize and sift half a pound of dry bay-salt, which is first to be gradually mixed with a pint of old verjuice, and then with half a pint of common gin. The diseased quadrupeds must be separated from the rest of the flock, and three large spoonfuls be given to each; the dose being repeated on the second or third succeeding day, according to the exigency of the case.

11. Staggers, in *Sheep*, is a species of apoplexy, arising from too great fulness of blood. It principally attacks young lambs, which fall down; and, if not timely relieved, they speedily perish. The mode of cure generally adopted by shepherds, is to bleed the creatures frequently in the

eye-vein, and to remove them to a coarse pasture, with a view to prevent the danger of a relapse.

12. Foot-Halt, is occasioned by an insect resembling a worm, two, three, and sometimes four inches in length. The first appearance of this malady is manifest by the lameness of the animal; a symptom which increases to so high a degree, as to prevent it from grazing. In consequence of pain, and want of food, the sheep lingers till at length it falls a victim to the disease, unless the worm be timely extracted; an operation that may be easily performed.

As soon as the animal begins to limp, the lame foot should be examined between the close of the claws, where the skin will be found perforated with a hole, through which the insect has worked itself a passage upwards, between the external membranes and the bone. In order to extract the worm, the claws should be moved in contrary directions, for a considerable time, till the insect gradually makes its way to the surface. This simple operation will be fully efficient, without any other application; and it is certainly preferable to drawing the worm out; as in the latter case there is always danger of its breaking off, and rotting in the sheep's leg, which would materially injure the animal.

The *foot-halt* occurs more frequently in wet than in dry seasons; generally in the spring and autumn, but seldom in the summer and winter. Sheep that are pastured in high, healthy grounds, are less liable to be attacked by this insect, than those which graze in low meadows, or marshy soils

13. Foot-Rot, a disease which is said to be contagious.

The first symptom of the disorder is manifest, when the animal affected begins to limp; though no injury will be perceptible on examining the foot, which is extremely hot.

The second stage of the distemper is a yellowish-white spot, that appears in the cleft of the hoof, spreads gradually, and becomes livid; destroying the hair, which in sound animals covers the foot. At this period, the diseased part acquires a disagreeable smell, and the lameness increases.

In the third stage, the malady sinks into the frog of the foot; the shell of the hoof loosens, and the frog is filled with fetid matter, that oozes out when pressed by the hand: a small tumor sometimes breaks out in the front of the leg, about one inch above the hoof, which, however, is easily dispersed.

In the last stage, the foot is so completely mortified by the cancerous humour corroding every part of it, as to become incurable; in which case, the skin is the only valuable part of the animal.

Through these different periods, the sheep affected retain their appetite, and feed apparently as well as when in health; but they very soon fall away, and continue to decline, till they have lost all their fat.—Notwithstanding their rapid decay, at the end of the second and the commencement of the third stage, they are so eager for food, that they even crawl on their knees for sustenance.

For the cure of this infectious disorder, different remedies have been prescribed; from which we select the following: the first was invented by the late Mr. Bakewell, the other by Mr. George Culley of Fenton, Northumberland.

1. Take 3 oz. of verdigrease; of vitriol, and common alum, 4 oz. each; white mercury 1 1-2 oz. and white copperas 1 oz. The whole is to be finely pulverized, and dissolved in a quart of white-wine vinegar.

2 Let 4 oz. of the best honey; 2 oz. of burnt alum reduced to powder, and half a pound of pulverized Armenian bole, be mixed in as much train or fish oil as will convert these ingredients into the consistence of salve: the honey ought first to be gradually dissolved, when the Armenian bole should be properly stirred in, after which the alum and train oil are to be added.

The parts affected may be rubbed with either of these compositions; unless the distemper has become incurable; but in the opinion of Mr. Arthur Young (from the 21st vol. of whose *Annals* we have extracted these recipes), the *red salve* of Mr. Culley, is more efficacious than Mr. Bakewell's liquid, having cured one or two diseased feet, where the latter had failed; yet Mr. Young always employs the liquid, previous to anointing the animals with the salve.

This malady, in general, arises from long grass in wet seasons; but, if sheep be suffered to lie upon their own dung, a fermentation will take place, and occasion either the *foot-rot*, or the *foot-halt*; to prevent which fatal disorders, those animals should be well littered, and kept with a strict attention to cleanliness.

14. Pelt-Rot, is a disorder in which the hair or wool falls off spontaneously. It arises from various causes, but more especially in consequence of a sudden change from scanty or bad provender to full feeding; also from a local weakness in the skin, which parts with the wool; and, lastly, from the Scab, loosening the

hair at its roots. This malady may be prevented by proper attention to the animals; by giving them wholesome food, and in regular proportions, particularly during the winter. Should it, however, originate from the scab, the removal of that distemper will also cure the pelt-rot.

15. RICKETS, in *Sheep*, a disorder which occurs chiefly in the county of Huntingdon, whither it is by some farmers supposed to have been introduced from Holland.

This malady is one of the most fatal that can happen in a flock; for, as its causes have never been clearly ascertained, all the remedies hitherto employed for its removal, have uniformly failed of success.

The first symptom that indicates the presence of the rickets is, a species of giddiness, in consequence of which the sheep appears unusually wild and ferocious; starting up suddenly, and running to a considerable distance on the approach of any person, as if it were pursued by dogs.

In the second period, the chief characteristic is a violont and inflammatory itching in the skin; the animal rubs itself furiously against trees, hedges, and the like, so as to pull off the wool, and even to tear away the flesh: no critical discharge, or cutaneous eruption takes place, and every circumstance indicates the most violent fever.

The last stage of this malady, is the progress towards dissolution, which at length follows; and the animal, after having reeled about, lain down, and occasionally eaten a little, falls a victim to a general consumption.

The rickets appear in the spring; and are *hereditary:* thus, after remaining latent for one or two generations, they break forth with increased violence. And as they appear suddenly, the utmost precaution of the most judicious graziers cannot detect the malady; so that no other choice remains, but immediately to cease breeding from the infected stock.

Having already observed, that the cause of the rickets is unknown, it is to be apprehended that the aversion evinced by breeders, to make proper inquiries, will probably contribute towards perpetuating this veil of ignorance. Nevertheless, we deemed it useful to state the symptoms that indicate the disease: such of our readers as may wish more fully to investigate this subject, may consult Mr. Comber's practical essay, entitled *Real Improvements in Agriculture,* &c. in which it is amply discussed; and an account is given of the steps that have been taken to ascertain the cause, and seat of the rickets in sheep.

16. GALL in *Sheep,* denotes a disorder, with which these animals are affected during the winter, and which is probably occasioned by severe frosts.

Although we have met with no remedy for the cure of this complaint, yet for its *prevention,* the following useful fact deserves to be recorded. Mr. Ellman, of Shoreham, Sussex, has observed, that by giving his sheep some hay in mornings of hoar-frosts, it preserves them from the *gall.*

17. FLUX, a disorder to which sheep are subject, when those animals, after having been kept on too short an allowance, suddenly come to their full feed. It is also sometimes occasioned by their eating the Fetid Chamomile, or May-weed. This disease, however, is not attended with any dangerous consequences, and generally disappears in the course of a few days, especially in dry weather. But, if it continue longer than a week, some sweet and well dried hay should be given them, and a decoction of clover-flowers, with the addition of a little barley-meal; and neither allowing them any salt, nor to feed upon saline plants near the coast, during their convalescent state.

18. The *Sheep-fagg,* is an insect well known to shepherds. Its beak consisting of two valves, is cylindrical, obtuse, and pendent, and the feet have several claws. These depredators live among the wool: they materially prevent sheep from thriving, in consequence of the severity with which they bite, and the blood they extract from the tortured animals; but, on account of the hard shell, or cover surrounding them, they are with difficulty destroyed—The remedy suggested by Sir Joseph Banks for curing the rot (which see) may also be safely applied to the extermination of the *Sheep-fagg;* as thus the quality of the wool will not be in the least impaired.

19. *Obstructions in the lacteal ducts of the udders of ewes,* after the lambs are yeaned. The whole udder is covered with hard tumors or knobs, which, in a short time become inflamed; and if the parts affected be not speedily relieved, a mortification will take place in the course of 24 hours; and the animal must consequently perish. As soon, therefore, as the tumors appear, it will be proper to clip off the wool closely to the skin, and to open the principal milk vessels with a razor, or similar sharp instrument; the morbid matter should then be expressed, and a little fresh butter applied to the wound. The ewe, thus affected, must be separated from the flock; and, though perhaps losing the use of one teat, she may be suffered to suckle her lamb; but,

if both teats be diseased, the latter must be reared *by hand*, and the dam fattened for sale.

Mr. Livingston, in the *Transactions of the Agricultural Society*, New-York, observes that the legs of sheep are furnished with a duct, terminating in the fissure of the hoof; from which, when the animal is in health, there is secreted a white fluid, but when sickly, these ducts are stopped by the hardening of the fluid. He has in some instances found, that the sheep were relieved, merely by pressing out the hardened matter with the finger. from the orifice of the duct in each foot, and thinks that it may in some cases, be proper to place their feet in warm water, or to use a probe or hard brush, for cleansing this passage

Sheep are farther liable to be *bitten*, *torn*, or *worried*, from the carelessness, or impatience of the shepherd; or, from his dogs not being sufficiently *broken*, as well as from the dogs of other persons; in consequence of which, the wool is often injured, and its value greatly reduced. Such accidents, however, may be prevented by proper care and attention.

Lastly, to preserve the health of sheep, it will be advisable that every farmer, or breeder, daily inspect his flock, and take particular care that their tails be kept perfectly clean: nor should they be folded two successive nights on the same spot; being more tender and obnoxious to disease than other quadrupeds.

No animal is more useful than the sheep, which supplies man with food and clothing, while it furnishes numerous poor families with constant employment, in the various branches of the woollen manufacture Its milk is very nutritious, and its flesh is a grateful and wholesome food; farther, the principal parts of the skin are advantageously converted into parchment; and the clippings, or shreds, are boiled into glue; a substance which is indispensable to carpenters, joiners, and cabinet-makers. The horns are formed into buttons, and various other articles of conveniency: the trotters afford, on expression, an oil which is usefully employed in several branches of the arts; and, when boiled, or baked, they furnish a nourishing repast. Lastly, their dung is a valuable manure; and even their bones, when reduced to ashes, constitute a principle ingredient in the compositions for artificial stones, for ornamental chimney-pieces, cornices, &c.

On account of these numerous useful purposes, the sheep has deservedly become an object of national consideration: it will, therefore, not be uninteresting to give a concise view of the different breeds, at present existing in Britain, and which is selected from Mr. Culley's practical *Observations on Live Stock*, 8vo. 2d edition, Robinsons, 1795.

		Average weight of fleece per lb.	Years old when killed.
1 Dishley	long wool	8	2
2 Lincolnshire	long wool	11	3
3 Tees-Water	long wool	9	2
4 Dartmore Natts	long wool	9	2½
5 Examoor	ditto	6	2½
6 Dorsetshire	fine short wool	3½	3½
7 Herefordshire	very fine short wool	2	4½
8 South-Down	ditto	2½	2
9 Norfolk	fine short wool	2	3½
10 Heath	coarse long wool	3½	4½
11 Hardwick	short wool	2	4½
12 Chevoit	fine short wool	3	4½

AVERAGE PRICES OF NATIVE BRITISH WOOL.

LONG WOOL.

Lincoln	*20*s*. per tod of 28 lb.	or	$8\frac{1}{2}$ per lb.
Leicester	21*s*. 6*d*. ditto,	or	$8\frac{3}{4}$

SHORT WOOL.

Norfolk	48*s*. 6*d*. per tod of 28 lb.	
South-Down		1*s*. 10*d*. per lb.
Hereford, trinded		2*s*. 5*d*.

To these different breeds must be added, 1. The improved Gloucester, or the Costwold Sheep, enlarged by the old Leicester Cross; producing full-sized and well-flavoured mutton: and, 2. The Staffordshire Cannock-heath sheep, which resembles those of the South Down. Both these breeds are said to be susceptible of great improvement by crossing, and have been highly recommended to the attention of breeders.

Beside the native kinds, or varieties, of this valuable animal, we cannot in this place omit to mention the *Spanish or marino sheep*. Numerous experiments were instituted, under the immediate superintendance of Lord Somerville, and the *Board of Agriculture;* which have been attended with the most desirable success. Nay, that patriotic nobleman lately performed a journey into Spain, with the sole design of collecting a number of the finest Spanish sheep: and thence imported *twelve* rams.

The following directions will be found useful, by those who are inclined to improve the breed of sheep *chiefly* for wool. They are taken from Dr. Anderson, and other late practical writers.

1. Fineness of pile and softness of texture, are the peculiarities chiefly wanted.

2. When two or more sheep are found in a flock, which are entirely equal in these respects, that one which has the fewest hairs through the fleece, ought to be preferred, for although these hairs may be separated, as the natives of Shetland experience, by letting the wool rise entirely from the skin, without being shorn, yet in large flocks that practice would be very inconvenient.

3. If fineness of pile and purity are equal, that sheep which has the closest pile, or thickest fleece, should be preferred.

4. If fineness, purity, and closeness of pile, be equal, prefer that which has the greatest uniformity in the texture of the whole fleece.

5. All the above named particulars being equal, the general shape and figure of the animal ought to influence the choice. A *round compact body*, a *full* and *deep chest*, *straight back*, *straight firm legs*, *neither very long*, *nor too short*; and a *strong hardy figure*, upon the whole, with a lively mild looking eye; are the particulars respecting shape, that should be preferred: but this circumstance should be a subordinate consideration to those already enumerated.

6. All other circumstances being equal, that sheep which is in the best condition at the time, if their pasture has been nearly equal, should be preferred.

7. If two sheep are equal in all the foregoing respects, that which is of the larger size, may be preferred.

8. Ewes should be chosen as nearly as can be found, of the same quality with the ram. It is only after the best breeds are once obtained pure, that experiments should be tried, to see what will be the effect of crossing with others.

9. In every case, the colour ought to be particularly adverted to, and though there may be exceptions, it will be found, that a pure white breed, is upon the whole, best calculated for general use, as white wool admits of being dyed of all colours with greater facility than any other. If, however, any one incline to try to improve a particular colour, it may be a very proper subject for experiment —But, in every case of this sort, the ram and ewes selected, ought to be exactly of the same kind, and should be carefully put apart by themselves, till such a quan-

* Sterling currency.

tity of this wool could be obtained, as might serve, to ascertain what were its peculiar qualities, and its intrinsic value. In no cases should any sheep be selected to breed from, that are spotted in any way, for this peculiarity can never be beneficial to the rearer.

Those who have not adverted to the effects produced by selecting proper breeds of sheep, for breeding from, but who have been accustomed to let their sheep run promiscuously, and breed together without any selection, can have no idea of the surprising effect that an attention continued for a few years, would have, on improving the wool, the shape, and the general hardiness of their whole flock; and will therefore be inclined to look upon these directions as unnecessary refinements:—but the farmer may rely, that these observations are the result of experience, and not of speculative reasoning; and that, if any of them shall make trial of selecting a few sheep, and of secluding them during the rutting season, from all others, they will themselves be astonished at the effects, and they would be very agreeably surprised, to find, that they might be able to obtain from 6 to 12 cents per pound more, for their wool, than their neighbour who was not careful. It deserves also to be mentioned as an important and well substantiated fact, that the sheep which carry the finest wool, if carefully selected, are in general equally hardy, and as easily fed, and carry fleeces of equal weight, with other sheep, yielding the coarsest wool.

A small size in sheep, is no way connected with the quality of the wool: the finest woolled Spanish or marino sheep, is a large well bodied hardy animal, and the Thibet sheep which carry the finest wool in the world is still of a larger size. Fine wool, therefore, may be obtained without diminishing the size of the carcase of the sheep in the smallest degree, and also without diminishing the weight of the fleece, or losing any other peculiarity that could render any particular breed desirable. This would, no doubt, require pains, and a careful selection of the best breeds, wherever they could be found, and an attentive and cautious procedure, but no one can easily imagine, how much can be done by attention in this respect. Mr. Bakewell, the famous breeder at Dishley, Leicestershire, in England, began with a few good sheep; and yet by a course of good management, brought his sheep, to a degree of perfection hardly credible by American farmers. Dr. Anderson continued his experiments but three years, and yet even in that time, he had some wool that measured full half a yard in length, which was equally fine with the best Spanish wool, and much softer to the touch. If such were the effects of only three years attention, in a situation that did not admit of an accurate seclusion of different breeds at the rutting season, what might be expected from a course of experiments conducted on a more enlarged principle, in a place where an entire seclusion of breeds could be easily affected, continued for half a century? No one can pretend to say to what perfection we might arrive.

Experiments made by various persons have clearly proved, that the permanent qualities of any breed of sheep can only be affected by a change in the parent stock, and that of course, if a new good breed be introduced into the country, it will infallibly be debased by intermixing with the native breed, unless a *careful*, and *entire seclusion* of them shall be made at the rutting season. Let the farmer, therefore, who is disposed to improve his wool, examine his present stock, and pick out all those of the finest fleeces, and part with the rest. Let him add to this stock, all those of equal fineness, which he may meet with among the droves; if he should find any sheep with a wool of a finer quality, let him buy these also, and if convenient, they may be kept, or let him part with his former stock, and keep his last purchase, and set them apart for the experiment. By persevering in this way, our farmers may be enabled in time, to rear, not only as fine wool as is obtained from any other country, but may also be able to conjoin with it every other valuable peculiarity, such as closeness of fleece, a good mould of carcase, hardiness, a capability of being easily fattened, largeness of size, and every other valuable quality, adapted to every peculiarity of situation of our country; or they may be enabled to ascertain the value of any particular breed of sheep, that might be suspected to possess particular excellencies, so as to enable those who are concerned, to speak with certainty of the particular value of each, and the circumstances in which one kind could be kept with greater profit than another.

One caution must be suggested, which observation proves to be highly necessary, with respect to the introduction of strange cattle among other cattle on farms: and that is, the danger of disease. The same thing may happen to sheep. When, therefore, any addition is to be made to the old stock, the strangers should be gradually introduced, carefully watched, and a separation of the diseased from the heal-

thy ought to take place, the first moment indisposition appears in the flocks.

The varieties of sheep are great. Some are distinguished for fineness of wool, and for flavour of flesh; others for short wool, bare bellies, and for bringing very early lambs; others for smallness of size, and superior fineness of wool; others, as Mr. BAKEWELL's breed, for small bones, fineness of flesh, lightness of offal, disposition to quietness, and consequently, to mature and fatten with less food, than other sheep of equal weight; and again, some for carrying long coarse wool, and their fat outside, and some for carring it within, and having the lean marbled with fat; and although our American sheep, have hitherto been almost universally permitted to have an unrestrained intercourse with one another, yet it is highly probable, that in some districts, sheep may be found possessing one or more of the above peculiarities, and when they do appear, endeavours ought to be made to keep the breed pure, or cautiously to cross it with others, that may possess some other valuable peculiarity. It is by a proper admixture of two breeds, with a judicious selection of the *best varieties* thrown out from them, that can insure a breeder success: to obtain which requires great attention, not only to know the best sheep, and of what descent when living, but in seeing them cut up after they are dead: for when the improvement of the carcase is the object, we should breed from the descendants of such only, as "*cut up well,*" for one injudicious cross may cost many years to repair the injury it may occasion, and the life of man is too short to allow of many such errors.

Having obtained a good breed of sheep, the next object of the farmer should be, to preserve it pure and unmixed—For this purpose, the most certain plan would be to keep no other breed upon his farm, for experience proves that during the rutting-season, no fences the farmer can rear, are sufficient to keep them separate. They therefore mix and degenerate, in spite of every effort that can be made to prevent it.

It has been generally supposed, that to prevent the degeneracy of any particular breed, it is necessary to breed from males and females not related to each other: but this is now found to be as great a mistake, as the prejudice respecting the necessity of changing seed, which has been so fully disproved, by Mr. JOSEPH COOPER of New-Jersey. Good animals and good seed, will always preserve their original excellence under the same circumstances, and experience has fully proved, that any one breed may be kept perfectly uncontaminated for any length of time, with all its distinctive peculiarities entire, merely by preventing an intermixture. It was by a careful attention to this principle, that the late Mr. BAKEWELL obtained such an ascendency over every other man in England, for the various breeds of his animals.

The food of sheep has a very considerable influence upon the flesh and fleece. They are particularly fond of sheep's fescue-grass, of yarrow, of rib-grass, narrow-leaved plantain, and of common melilot—Salt pasture is also highly beneficial in heightning the flavour of the flesh, and increasing the fineness of the wool.

The sheep of the Shetland islands, notwithstanding the inclemency of the weather, produced wool of the finest quality. We also know, that the sheep from Cape-May, Shrewsbury, and the high lands of Neversink, in N. Jersey, produce the finest mutton and wool, of any brought to our market.

Salt is essentially necessary to sheep, and should be freely given. In Spain they allow one pound and a half a-season to each animal. It is given to them upon flat stones, placed about 20 feet from one another. This practice should never be neglected.

The citizens resident in the lime-stone districts of the country, should turn their attention to the raising of sheep: as they will be saved the expence of salt, which may be an object where a large flock is kept.

In England, no one attentive to the preservation of the quality of wool, ever puts a ewe to a ram before the second or third year of her age. This practice ought to be carefully followed in the United States, for obvious reasons. The strength of the animal by that time, is perfect, its character, disposition and peculiarities are fully evolved, and of course will be capable of more completely transmitting them to its offspring, than by becoming a parent at a more early period, and before its constitution is fully formed, and before its native good qualities are rendered apparent.

It is of great importance to the beauty of the animal, that nothing interrupt its growth during the first year.

By experiments it appears that the first cross, of a new breed, gives to the lamb half of the ram's blood, or 50 per cent,

The second gives	75 do.
The third	$87\frac{1}{2}$ do.
The fourth	$93\frac{1}{4}$ do.

At which period it is said, that if the ewes have been judiciously selected, the difference of wool between the original

stock, and the mixed breed, is scarcely to be discerned.

Lord SOMERVILLE, says, that "In addition to a most admirable systematic management of the flocks of sheep in Spain, the superiority of the wool may depend upon *three* circumstances. 1. The use of salt: this prevents the injury arising from an *acidity of the stomach*, a serious disorder, and common to sheep, particularly when stocked on green floaty food, such as turnips, vetches, or young clover. The salt is spread on tiles or slates, among which the sheep are driven. On lime-stome soils, none is required. 2. To the practice of rubbing into the wool, red or yellow earth, in September. It is supposed to mix with, and qualify the perspiration, (which would otherwise give an asperity to the wool,) and to form a coat impenetrable to rain or cold. 3. To their changing their climate with the season, so as to preserve an equal temperature of air. Spanish flocks are never let out of the fold to feed, until the morning dews have been evaporated. This prevents the *liver-rot:* probably the *foot-rot* of England is owing to the dews, as this disease never appears before the 25th of August.

Merino sheep are sweated a day or two before shearing, to make the wool part easily from the body; and are carefully housed during the night, or in cold, raw weather, for some days after shearing.

In England, Lord S. finds, that the sheep with large throats are not good in their skins, and evince no aptitude to fatten; the Ryeland breed is an exception. This last, like the Spanish breed, carries wool of such high value, as to counterbalance the illimpression of throatiness. Their skins are full as good, and in some instances more *clear and rosy, a sure token of vigour* and consequent disposition to fatten. Dr. GARNETT's analysis of the substance rubbed on the wool of the Spanish sheep, proves it to be a kind of Fuller's earth (but not an *ochre)* of a soapy nature.

Lord S. says the Spanish rams have a buff tinge in their countenance, they may reach 17 lb. a quarter, when tolerably fat. The ewes are not low on their legs, are *very fine in bone*, and may reach 11 lb. a quarter."

The following excellent extract, is part of a paper presented last year, to the *Boston Society of Agriculture*, by DAVID HUMPHREYS, the late minister of the United States to Portugal, which it is to be regretted, has not been given entire. Mr. H. has laid the foundation for great wealth to this country, by bringing over with him, on his return from Spain, one hundred Merino sheep, which he has let out on the most liberal terms. As a compliment for the meritorious act, the *Boston Society* has presented Mr HUMPHREYS with a gold medal.

"In Spain, two distinct species of sheep have for ages existed, the one named Merinos, famous for their short and fine wool, peculiarly fit for carding; the other denominated Churros, distinguished for their long and coarse wool, more suitable for combing. The former are so precious, as to be sought with eagerness by all who wish to meliorate the staple for the woollen manufactory in any country of Europe; while the latter, though much larger in size, are in so little estimation as never to be procured for exportation. My statements and remarks will be confined to the Merinos. The height of the male is about the same as that of the ordinary breed in this country. The head appears rather bigger and straighter. The ears are very small. The eyes remarkably bright. The horns curved in a spiral turn. The neck is short. The chest broad. The members more compact and thick, than those of our former breed of Sheep; and the carcase is thought to have smaller bones and to be more rounded in the hinder part. The body, face, and legs, are covered with a delicate fleece, which grows amazingly thick, without any mixture or coarser locks of hairs. This fleece is remarked to be much more impregnated than that of any other breed, with an oily substance, apparently exuded in perspiration. This animal is perfectly gentle, but quick, firm, and regular in all his movements. The female is considered generally as having the more characteristics of the pure blood, in proportion as she approximates to this description—yet the ewes are commonly destitute of horns.

"A few well attested facts will serve to shew the value of this race. None of the superfine cloths made in England, France, or Holland, can be fabricated without the mixture of a certain portion of this wool—The price is more than twice as high per pound, as it is for ordinary kinds. I shall mention, in another place, the increased weight of the fleece, when this breed are transferred from Spain to another country, upon the testimony of those concerned in their management—That the flesh is not less succulent or well flavoured than the best English or American mutton, I have had frequent opportunities to decide for myself. It is understood that the Merinos are more easily maintained and fattened than the taller

and larger breed, insomuch that there are persons acquainted with both breeds who calculate that 200 of these small boned and short legged sheep may be kept in tolerably good condition, where 20 of the other would suffer for want.

"To establish a strong presumption in favour of the following point, viz. that the race then contemplated to be introduced into the United States, was likely to preserve all those qualities which constituted the original superiority of value, I need only refer to the propagation of a breed from the same stock, with fleeces augmented in quantity, and undiminished in fineness, in Great Britain, France, Holland, Switzerland, Germany, Denmark, and Sweden. In the most northern climate to which they have been carried, they have supported the cold perfectly well, and even without suffering any injury from having been in some instances buried for a time under the snow—At the national farm of Rambouillet, in France, they are reported, on good authority, to have not only resisted the unfavourable influence of a situation naturally too low and moist, but to have preserved their wool in all its original fineness, and to have increased the weight to an astonishing degree.

"It is a fact confirmed by experience beyond contradiction, that the quality of the wool does not depend on the quality of the pastures in Spain, because the same pastures have maintained, from time immemorial, two different breeds, which have never assimilated; one remarkable for the shortness and fineness, the other for the length and coarseness of the wool. It is moreover equally well proved, that the quality does not depend on the journies which the greater part of the Merinos make annually, because there are other flocks of the same race which remain perpetually in the same district, and whose fleeces are of the same consistence precisely as the others. The flocks that do travel, or do not travel, which are nourished with plentiful food, and taken good care of, by excluding the deformed, sick and weak, from becoming breeders, are preserved in all the purity of the original stock—while those in either predicament, migrating or resident, which are subjected to feel the effects of scarcity and negligence, invariably degenerate.

"The vigilance of the Shepherds, in remaining day and night with their charge, in reserving the best formed and finest woolled only for breeding, and in knowing and attending to each individual of their flocks, has, doubtless, contributed much to preserve them from degenerating down to the present day.

"This breed, like most of all others, thrives best in uplands and short pastures; but it is reputed to be so singularly hardy, as to endure rain, snow, and cold as well as any northern race, and to support itself in parched southern climates, by feeding on weeds and vegetables which most others would not taste—Without entering into the detail of enriching the land, on which they graze or are folded, by their manure, especially where a rotation of crops is systematically pursued, I should not omit to mention, it has been asserted, that a moderate sized farm, for example, a hundred acres, skilfully manured, may be made to maintain 100 sheep, and moreover, to produce as much in crops as it would have done had it been employed only in cultivation, and not charged with their nourishment.

"That rams have been let for the season in England, for from 100 to 1000 guineas each, is a fact sufficiently known, to those who are acquainted with the history of agricultural proceedings in that country; and it demonstrates conclusively the wonderful passion that prevails for bettering the breed. The successful experiments in France, on the same subject, have been announced in a manner which demands credit. At Rambouillet, a farm originally appropriated for making improvements by the ancient Government, which is represented not to be a very good position, on account of its humidity, a pure Spanish stock has been maintained for many years by the attention and care of the superintendants, not only in a perfectly healthy but gradually improving condition, in such sort that the quality of the wool is as fine as that of the best Merinos actually in Spain, while the quantity is considerably more than doubled. Where large flocks are kept in the last mentioned country, the sheep do not produce, upon an average, more than from two to three pounds. The rams at Rambouillet, yield from 10 to 12, and the ewes from 5 to 6 each. From this stock, many small flocks, both of the pure and mixed breeds have descended.

"Several intelligent authors in Europe, who have treated of the most speedy and efficacious modes of improving wool, have stated, that, where the smallness of the original stock of Merinos prevents so rapid a propagation of the pure race as could be wished, a mixed breed may be produced by Spanish rams, and well chosen ewes of the country, whose descendants, in the fourth or fifth generation, will yield fleeces nearly or quite as fine as the first quality of those which are produced in Spain."

Shearing Lambs.—It has been a question, whether the practice of shearing lambs, is prejudicial or useful. By a publication addressed to the *Philadelphia Society of agriculture, (American Museum,* vol, 9, p. 111,) by Dr. LOGAN, it appears, that he sheared three lambs in August, which had been yeaned the preceding March, and that the wool, taken the following spring from the same animals, though it was not so long as that of two others, yeaned at the same time, but not shorn until the spring after, yet the fleeces were much thicker, equally fine, and not the least matted :—and he is so convinced of the profit and utility of the practice, that he intends to continue it. Mr. JOHN PHILIPS, of the township of Pittstown, Luzerne county, Pennsylvania, has also announced in the Wilkesbarre Gazette of August 27, last, that "he sheared from six lambs, fourteen pounds and four ounces of wool; and that he is convinced by seventeen years experience, of the great advantage in shearing lambs: although the wool will not be so long the next spring, yet it will be much thicker than on those which are not shorn; and the lambs that are shorn will not loose their wool like those that are not shorn. Besides shearing will relieve them from ticks, and they will certainly grow better and make larger sheep." Mr. P. shears his lambs *soon after the new moon,* in the last of July, or first of August.

The testimony of two American farmers, (and that of others, might be here added) deserves attention; and yet it may be well to state, that from a report made by TESSIER and HUZARD, concerning the flock of Spanish sheep at Rambouillet, (the French experimental farm) it appears that some sheep were allowed to be two years without being sheared, and their fleeces were found to be twice as heavy, and twice as long as the yearly fleece of those, which had been sheared twice in the same period; nor did the animals themselves appear to be at all incommoded.

Mr. Chancellor LIVINGSTON adds another reason given him by Mr. BOURGEOIS, the superintendant of the French national farm, for waiting till the second year before shearing, viz. that the ewes are worth less than the wool they yield, and that the weight of the first fleece at the age of 18 months, is equal to that of the two shearings in the old way.

The state of VERMONT has set a praise worthy example to the other states, by a law passed last year, deducting from the poor man's poll tax the full of its amount, on his proving that he keeps and shears 20 sheep; the law likewise protects the poor man's last ten sheep from attachment or execution.

See an *Essay on Sheep,* by Robert R. Livingston L. L. D. See also the *Shepherds Guide* by Samuel Bard, M. D.

Goat. A genus of animals, comprising more than 30 species, only one of which is reared in this country, namely, the *Hircus,* or common goat, a native of Mount Caucasus, in Asia, whence it has been dispersed through Europe.

This species has arched and keeled horns, with a long beard, and is peculiarly attached to the company of man, even in its wild state. The females generally bring forth one or two, and very seldom three kids, after a gestation of about five months; they attain an age of twelve years.

Goats are sensible of carresses, and display a remarkable attachment to their friends. They are stronger, more nimble, and less timid than sheep; possess a lively, capricious and wandering disposition; and delight in elevated and solitary places, frequently sleeping on the points of rocks and precipices—These animals are more easily supported than any others of the same size; for there are few herbs which they will not relish—Nor are they liable to so many disorders as sheep; and, though able to support the vicissitudes of heat and cold more easily than the latter, yet they are very susceptible of severe frosts, which they endure with less difficulty in the society of other animals.

Goats emit, at all times, a strong and disagreeable odour, which however is not without its use: for, if one of these animals be kept in a stable, it is affirmed that it will be an effectual preventive of the *staggers,* a disorder which is often very fatal to horses. This influence of the goat is not, as Mr. Marshall judiciously observes, in his "*Rural Economy of Gloucestershire,*" merely that of a charm; for the staggers are evidently a nervous disorder. Odours, in many cases, operate beneficially on the human nerves, and probably the strong scent of the goat has a similar effect on those of the horse; a conjecture which is partly corroborated by the practice adopted in Northumberland, where a few goats are generally mixed with the sheep, for the preservation of the health of the flock. It is also well known, that the former with safety eat plants, which would be destructive to sheep and other animals.

Although the food of goats is attended with little expence, as they maintain themselves on the most barren mountains, yet their produce is of considerable

value. The whitest wigs are made of their hair, for which purpose that of the Welch he-goat is in the greatest repute —Their fat is in equal esteem with the hair, and candles are made of it, which, in whiteness and quality are said to be superior to those of wax; their horns af ford excellent handles for knives and forks; and their skin is well calculated for gloves, especially that of the kid, which is dressed abroad, made into stockings, bed-ticks, bed-hangings, sheets, and even shirts.

The flesh of these animals, however, is hard, and almost indigestible: hence the meat of kids only should be eaten, as it is more tender, and affords good nourishment. Goat's-milk is sweet, nutritive, and medicinal; it is an excellent substitute for that of asses; and, when drank warm in the morning and evening, with a tea-spoonful of hartshorn, for several weeks, it has been productive of benefit to phthisical patients, who were not too much reduced—Cheese prepared from goat's milk is much valued in mountainous countries, after it has been kept to a proper age; but possessing a peculiar flavour, it is to some persons very unpleasant; nor is it more easily digested than any other kind of caseous matter.

Hog A genus of animals consisting of six species, the most remarkable of which is the *scrofa*, or common hog. Its body is covered with bristles, and it has two large teeth, both in the upper and lower jaw. In a wild state, this creature is of a dark brinded colour, and beneath the bristles is a short soft hair; its ears are more diminutive than those of tame hogs, which are long, sharp-pointed, and hang down; the colour of the latter is generally white, though sometimes mixed with other shades.

The hog is proverbially the most rude and brutal of quadrupeds: its habits are gross, and such is its gluttony, that it devours every thing indiscriminately. But, though it be the most impure and filthy of animals, its sordidness is useful, inasmuch as it swallows with avidity, refuse and offal of every kind, so that matters which would become a nuisance, are converted into the richest nutriment.

Sows generally breed at the age of 18 months, or two years, and bring from five to ten or more pigs, twice or oftener in the year, after a gestation of four months.

As hogs, from their voracious nature, will eat almost every thing, they are very generally reared in all situations, being quickly and cheaply fattened. In miry and marshy grounds, where they delight to wallow, they devour frogs, fern, the roots of rushes, sedge, &c. In the drier countries, they feed on hips, haws, sloes, crabs, beech-mast, chesnuts, acorns, &c. on the last of which they thrive exceedingly. Of late years, the management of these animals has become an object of attention. Clover, potatoes, turnips, cabbages, and carrots, are, it is well known, articles with which they may be fed, and even fattened, at a small expence. Parsnips are of considerable utility for this purpose, and probably the roots of the white-beet, if it were fully tried, would be found still more useful; for experiments have shewn, that it contains a considerable proportion of saccharine matter, and may be cultivated with very little difficulty, Cos-lettuces are likewise eminently serviceable, especially for young pigs, which when fed on them, may be weaned a fortnight earlier than is usual: Pease also afford an excellent food for fattening, and if duly mixed with salt, will render the animals fit for sale at the end of five weeks.

In the vicinity of London, vast numbers of hogs are annually fattened with grains from the distilleries: such pork, however, does not take the salt so readily as the flesh of those pigs which have been fed with more substantial food, and been driven to the market from a considerable distance.

Hogs may with great advantage be folded on wheat, where the soil is loose, light, and friable; for they will drop a considerable quantity of dung, and tread the looser parts of the land so closely together, that it will not *hove* during summer; nor will the wheat be *root-fallen.* Particular care, however, ought to be taken, that these animals be *well ringed;* an operation that ought to be performed as early as possible.

The diseases to which hogs are subject, are but few: nor are they often troubled with them. The chief are, 1. The *measles,* said to be perceptible only in the throat, which, on opening the mouth, appears full of small tumors, that in some cases are visible externally. The remedy usually applied is the powder of crude antimony, in small portions, which generally removes the affection. 2. The *fever,* which is also called the *heaving of the lights:* it is cured by giving the diseased animal a mixture of oil and brimstone: 3. the *Mange,* a disease affecting dogs and swine, in a manner similar to the itch in the human body; and arising from an insect that works its way beneath the uppermost skin; where it causes so great an irritation, that the animals rub

or scratch themselves, tearing off the head of the pustule, which occasions a scab and, in a short time, an ulceration. This disorder, especially in dogs, originates from too high feeding, want of exercise, and an opportunity of refreshing themselves with dog's grass; from being starved at home, so that the animals are compelled to devour carrion, and excrements abroad; from want of water, or neglect of cleanliness in their kennels. It is induced in swine, by suffering them to lie in their styes, without clearing away their ordure.

As the malady is entirely situated in the skin, the cure may be effected in dogs, by giving them a small quantity of fine pulverized sulphur, either in milk, or incorporated with butter, and rubbing them daily, for the space of a week, with an ointment consisting of sulphur and hog's-lard; to which should be added a small portion of oil of turpentine. Another remedy is obtained we are told by boiling four ounces of quicksilver in two quarts of water, till the quantity be reduced to one half: with this liquid the animals are to be washed regularly, and ought also to take a small draught of it every day, during the continuance of the eruption.

With respect to the mange in hogs, Dr. Norford recommends the following ointment, which seldom fails to effect a perfect cure, provided it be properly applied, and the animals be kept clean, after the disease is removed—Take three ounces of hog's-lard, one ounce of fine flower of sulphur, two drams of white hellebore, newly pulverized, and half an ounce of the water of kali, prepared in the shops. These ingredients are to be thoroughly incorporated, so as to form an unguent; the whole of which is directed to be rubbed on the animal at one time, and is said to be sufficient for a hog of six or seven stone: if the ointment be properly applied, there will be no occasion for any repetition—Should, however, a slight cough affect these quadrupeds, after the cure is performed, it will be necessary to give each, according to its size, from half an ounce, to an ounce and a half, or even two ounces of crude antimony, properly levigated and mixed with some of his daily food, for the space of ten days or a fortnight, by which simple remedy, the hogs will be effectually restored.

When these animals have been long neglected, their necks, and various other parts of the body become affected with loathsome chaps or cracks. In this case, the best remedy is, to anoint the ulcerated parts every three or four days, till they are healed, with a little tar-ointment, prepared by mixing equal parts of tar and mutton suet over a gentle fire, and straining the mixture while hot. But the most certain preventive of the mange, and its subsequent disagreeable effects, is the strictest attention to the health and cleanliness of the animals. For this purpose, every part both of the kennel and of the stye ought to be thoroughly swept, before they are littered with fresh straw; nor should a clean bed be spread over a foul or dirty one, as is too frequently the case with careless and negligent servants; who, regardless of their master's interest, thus eventually cause the destruction of many valuable dogs and swine. 4. *Murrain* or *Leprosy*, a contagious disease incident to cattle and swine; it is known by the animals hanging down their heads, which are swollen; by short and hot breathing; palpitation of the heart; staggering; an abundant secretion of viscid matter in the eyes; rattling in the throat; and a shining tongue

In the 36th vol. of the *Annals of Agriculture,* the following recipe is inserted for the *murrain in hogs:* A handful of nettles is to be previously boiled in a gallon of small-beer, when half a pound of flour of sulphur, a quarter of a pound of elecampane, three ounces of liquorice, and a quarter of a pound of aniseeds, are to be added in a pulverized state. This preparation should be administered in milk, and the quantity here stated, is said to be sufficient for six doses.

Hogs are very valuable quadrupeds, and their flesh furnishes at all times an agreeable meat. (See Bacon and Ham.) In a fresh state, it is called *pork,* and affords a wholesome and nourishing food to a *sound* stomach, when eaten in moderation, with sub-acid vegetables or sauces. Their lard, or fat, is applicable to various purposes, both culinary and medicinal. The blood, intestines, feet, and tongue, are all used in the kitchen; though the first is indigestible. The fat of the bowels and web, which differs from common lard, is preferably employed for greasing the axles of wheels. The bristles are made into brushes, pencils, &c. the skins into sieves; yet the latter might be more advantageously tanned, and converted into shoes, as is the practice in China, where all the shoes sold to the Europeans at Canton, are made of hogs'-leather, the hair being previously burnt off with a red-hot iron.

The dung of swine is reputed to be next in value to that of sheep, and is particularly useful in destroying that pernicious weed, the common coltsfoot.

As hogs are animals of extensive utility, we trust it will not be uninteresting to point out those remarkable breeds which amply repay the expence of fattening them.

1. The *Berkshire* hog is spotted red and brown, attains a large size, has small ears, short legs, and very broad sides. They are highly valued; but, as they grow uncommonly large, no person should attempt to keep them, unless he be provided with a sufficient stock of food; as otherwise they will dwindle away, become diseased, and yield less profit than a smaller kind.

2. The *Shropshire* swine grow to a large size: they are generally white, have short legs, and long ears, which hang down upon their cheeks. This is a fine breed, much prized and bears a close resemblance to

3. The *Northampton* hogs, which are white, have very short legs, and attain an extraordinary size, especially those reared at Naseby. They are chiefly distinguished by their ears, which are of an enormous size, much larger than those of the preceding breed, and sweep along the ground, so as almost to blind them.

4. The *Chinese* breed (which is one of the most profitable kinds of hogs introduced into this country) is very hardy: will live on less food than any of the animals already mentioned; and seldom appears lean. They are mostly white, attain to a large size, and will *fatten well* on food that would *barely keep* other hogs. —To these may be added the *Suffolk* breed, which, in the estimation of some persons, is the best; and the *Leicester*, which is much fatter than that of Suffolk, but is said to produce *very few* pigs.

5. The *Large Spotted Woburn Breed*, introduced by the late duke of Bedford—from the experience of the earl of Egremont, and other able breeders, it clearly appears, that these animals are superior to the Suffolk breed; the former being not only more hardy, but also more prolific, and attaining double the size, in the same period of time.

6. The *Rudgewick Hogs*, are thus denominated from a village on the borders of Surray and Sussex: this race of animals is remarkable for the astonishing weight they attain, in the course of two years, which exceeds that of other swine at a similar age, in the proportion of at least two, and often three, to one. Hence, they deserve to be more generally reared, and their number ought to be increased, because they repay the expence of their keeping more speedily than any other breed.

As many frauds are practised at markets and fairs, on the unsuspecting farmer or cottager, in the act of buying or selling hogs, we shall briefly communicate a few hints, that may furnish some rules for guarding against imposition.

In purchasing *lean* hogs, the most certain method is to judge by weight. If, therefore, a farmer were to weigh a few lean pigs which were about the size of those he intends to purchase, he would obtain some standard on which to proceed, and will consequently be able to bid a fair price in the market.

With respect to *fat* hogs, it has been proved from repeated experiments, that every 20lbs. live weight will yield, when killed, from 12 to 14 nett weight. In those which do not exceed 12 stone (14lbs. to the stone,) the weight will be 12lb; but, in larger animals, it will in general amount to about 14lb. If, therefore, a farmer weigh them alive, he will not only know the clear profitable weight when killed, and consequently its value, but he will also, by weighing the animal every week, be able to ascertain the proper time to slaughter, or dispose of it to the best advantage; for, when the hog ceases to acquire that daily increase which renders it profitable, the best course that can be followed is, to kill him immediately.

Mr. Billingsley prefers large hogs to small, for profit: and observes, that small growing pigs ate nearly as much food as the large full-grown hogs, and yet they did not appear proportionably to improve either in size or fat; that advantage was derived from mixing up a quantity of meal a week or two before it was used; that no kind pay more for food than splayed sows; they fatten quicker and on less food.

In April 1769, a hog was killed at Williamsburg, Virginia, which weighed 1050 lbs. after the blood, bowels, and hair had been taken from him. It is supposed he weighed upwards of 1200lbs. when alive.

In March 1787, another hog was killed at New Port, Rhode Island, which weighed, when gutted and dressed 834 lbs. The length of the animal is said to have been nine feet, and height six feet.

The owners of these hogs were guilty of a very unpatriotic act, in sacrificing animals which would have been so highly valuable for breed. In future it is to be hoped, a similar error will not be committed.

" A sow kept at Hollowmire, near Ul-

verston, only four yesrs old last September, has farrowed 229 pigs, which is on an average of 57 per year; and except at the first time, always brought up thirteen. Within 19 weeks and three days she has farrowed twice. The animal went to the male the next day after the pigs were taken away, which was done when they were three weeks old

Parsnips are said to be highly fattening for hogs, and to give a fine flavour to the meat. This vegetable abounds with sugar, and therefore must be nourishing; but it is probable that Indian Corn would be required to harden the flesh before killing.

The economy of feeding with boiled food has been mentioned; though no direct experiment was adduced to support the opinion, yet the following comparative experiment settles the point. Mr. Timothy Kirk of York Town, Penn. fed one pig with boiled potatoes and Indian corn, and another with the same articles unboiled. The two animals were weighed every week, and the difference between them was as 6 to 9. The experiment was continued several weeks, and the animals alternately fed upon boiled and unboiled food, with an uniformity of result, which sufficiently proved the very great profit arising from boiled food.

The little care required to raise the hog, renders it of very great importance in almost every part of the world. In Virginia and the Carolinas, the hog runs at large in the extensive forests of those countries, feeding on grass, roots, and nuts, till they are in a suitable condition for market, when they are decoyed into traps or pens, and often their fat has been hardened by more substantial food; they afford the neighbouring states an abundant supply of bacon and smoaked gammon, which from the peculiarity of its nourishment and preservation, is possessed of a flavour unequalled in richness and delicacy by any in the world. In the maritime parts of the United States, vast quantities of its flesh are preserved, and exported to various parts of Europe and the West Indies, thus affording a very important article in commerce.

Dog. A genus of animals supposed to be originally natives of China, and consisting of more than thirty species, of which that most generally known is the *familiaris*, or domestic dog: this again produces several varieties.

Dogs are remarkable for their great docility, fidelity, and affection for their master. These useful creatures guard our houses, gardens, and cattle, with spirit and vigilance. By their assistance we are enabled to take both beasts and birds, and also to pursue game through the waters as well as over land; nay, the Norwegians render them also useful in fishing.

The dog is an animal of quick motion, and remarkable for travelling long journies. He easily follows his master, whether on foot or on horse-back, for a whole day; and, when fatigued, does not sweat, but lolls out his tongue. It is peculiar to dogs, before they lie down, to run about in a circular direction, with a view to discover the most proper situation for rest. They sleep little, frequently starting, and seem to hear with more acuteness, than while awake.

Dogs possess the sense of smelling in a very high degree. They can trace their master by the smell of his feet in a church, or in the streets of a populous city. In a savage state they are of a fierce, cruel, and voracious disposition; but when civilized, and accustomed to live in the society of men, they acquire every endearing quality. Gentle, obedient, submissive, and faithful, they appear to have no other desire than to serve and protect their master. These qualifications, added to their very great sagacity, justly claim the esteem of mankind. Accordingly, no animal is so much caressed or respected: in short, dogs are so tractable and so much disposed to please, that they assume the very air and temper of the family to which they belong.

Proper management of Dogs.—As these are, at all times, very valuable animals, it is matter of some importance to take care of their health. This depends much on their diet and lodging: the frequent cleaning of their kennels, and giving them fresh straw for their couch, are highly necessary; or, during the summer, deal shavings may be substituted for straw, as the former will prevent the breeding of fleas. If they be rubbed with chalk, and brushed and combed once or twice a week, they will thrive much better; the chalk will clear their skin from all greasiness, and they will be less liable to the disorder called the *mange*.

Dogs are of a very hot nature; hence they should always be provided with clean water, that they may drink when thirsty. With respect to food, carrion is by no means proper for them, as it must hurt their sense of smelling, in which their excellence in a great measure consists. Barley-meal, the dross or grossest part of wheaten flour, or both mixed together, with broth or skimmed milk, afford very wholesome nourishment. On account of the sanguine constitution of these animals,

the greatest relief to them in summer is Couch-grass, or DOG'S-GRASS, to which we refer. Those who keep a complete kennel of dogs, should purposely cultivate this plant, in a place into which they may be turned every morning: here they will eagerly eat it, to relieve the disorder to which they are subject, and thus to cure the uncommon heat of their blood.

These animals are liable to various diseases; of which we shall mention only the following:

1. *Bites* and *stings*. If dogs are bitten by any venomous reptiles, such as snakes, vipers, &c. the blood should be squeezed out, and the part washed with salt and urine: a plaster composed of calamine, pounded in a mortar, and mixed with turpentine and yellow wax, till it acquire the consistence of a salve, should then be applied to the wound. A draught, consisting of an ounce of treacle dissolved in wine, if given to the animal affected, will greatly contribute to its recovery.

2. *Mange*. See this disease in the preceding article, *Swine*.

3. *Poison*. If there be reason to suspect that a dog is poisoned with *nux vomica*, (which is often employed for that purpose by warreners, and causes convulsive fits,) the most effectual remedy is to make him swallow, without loss of time, a considerable quantity of common salt, dissolved in the smallest proportion of water: this simple remedy may be administered by opening his mouth, and placing a stick across, to prevent him from shutting it, while his throat is filled with the solution. Thus, by holding his mouth upwards, a sufficient dose may be introduced, both to purge and vomit him. As soon as the stomach is properly cleared by a free passage downward, some warm broth should be frequently given to relieve his extreme faintness, which otherwise might prove fatal.

4. *Worms*, a disorder with which young dogs in particular are very frequently troubled. All bitter substances are so offensive and nauseous to worms, that they are often voided in consequence of the animals taking two or three common doses of aloes, in the course of a week. Should this remedy fail, an ounce of the powder of tin, mixed up with butter, may be given in three portions, which generally destroys the worms, together with their seed.

5. *Coughs* and *Colds*. Dogs are very subject to a cough, attended with extraordinary paroxisms of choaking, which is often the consequence of a cold. In this case, it will be necessary to bleed the animal affected, in small quantities; but if the disorder proceed from what is called the *distemper* in dogs, and they appear to be very low in spirits, blood letting must not be attempted. Meat-broth, or milk-broth warmed, should then be the principal part of their diet, and the following medicine administered: Take flour of sulphur, cold drawn linseed oil, and saltpetre, of each one ounce; let them be well mixed together, and divided into four doses; one of which is to be taken every other day. Meanwhile, the creature affected should be furnished with plenty of clean straw to lie upon, and likewise swallow, at least, one spoonful of honey every day.

6. The *scab*, or *itch*, though a rare disease in dogs, is sometimes very obstinate: it may, however, be easily cured by an ointment made of hog's lard and sulphur, with which a part of the back of the animal should be rubbed every day, and the application gradually extended, till the whole back from head to tail, and at length all the affected parts, have been anointed. Thus, the requisite portion of sulphur, which is a specific in those cases, will be introduced into the system, both by absorption, and the constant licking of the diseased creature.

7. *Madness* frequently happens in hot summers, or very cold winters; and is supposed to be occasioned chiefly by suffering this faithful animal to feed upon putrid meat, without supplying it with sufficient water; but more probably originates from a specific contagion, like the small pox, &c.

This virulent disorder does not in general, manifest itself for a considerable time after the bite, for, though in some instances it has commenced in seven or eight days after the accident, the patient often continued in health for twenty, thirty, or forty days, nay, sometimes for several months. If the wound be not prevented, it will in most instances, be healed long before the symptoms of the disease appear.

In order to ascertain whether a dog is really infected with that distemper, the following particulars deserve attention. Several days previously to the invasion of the disorder, the animal becomes sullen and shows equal indifference to his master, his food, and drink. His ears and tail droop; instead of barking, he growls and snaps at every surrounding object, runs about irregularly, is no longer able to distinguish his master from strangers, and lolls out his tongue, which is parched, and of a livid hue. At length, he drops down suddenly, starts up again, bites whatever seems to obstruct his passage, and in this condition he seldom sur-

vives twenty-four, or, at the farthest, forty-eight hours.

No danger is to be apprehended from the saliva of a dog falling upon the skin; nor from the breath being received into the lungs. The saliva of a dog must be applied to a *broken* surface to infect. The mere insertion of the tooth of a diseased dog, covered with saliva, into the flesh, is sufficient to produce the disease; and the late Dr. Hutchinson relates a case in which it came on in consequence of a dog merely licking a sore on the leg. Another case is recorded in the *Medical Repository*, of the disease being produced by a little dog licking a sore in the ear. In both cases the dogs discovered no symptoms of madness at the time. (MEASE.)

The practice of worming dogs to prevent their being attacked by madness is highly absurd, because quite useless; and, when attacked, no specific remedy has yet been discovered for the cure of this dreadful disorder.

ANNEALING. When a substance melted or nearly in a state of fusion, is cooled very hastily, its texture is so much altered, that, if a ductile metal, it loses much of its malleability, and cannot be extended far under the hammer without cracking; or, if a brittle metal, a glass, or vitrescent mixture, it is liable to fly to pieces by a very slight change of temperature or external injury. To avoid this the process of annealing is resorted to, which is nothing more than cooling the heated or melted substance as slowly and equally as possible, often in a separate furnace of the requisite heat, and sometimes called an *annealing oven*. The utility of annealing is shewn very conspicuously in the manufacture of *Glass*, the casting of *Speculum Metal*, or the beating of *Gold*.

The difference between unannealed, and annealed glass, is very remarkable. When a glass vessel that has not undergone this process, is broken, it often flies into a small powder with a violence apparently disproportionate to the stroke which it received. In general, it is in greater danger of being broken from a very slight blow, than from a more considerable one. Such a vessel will often resist the effects of a pistol bullet dropt into it, from the height of two or three feet, yet a grain of sand falling into it, will break it into small fragments. This sometimes takes place immediately on dropping the sand into it, but the vessel will frequently remain apparently sound, for several minutes after; when, without the least touch, it will suddenly fly to pieces. If the glass be very thin, this effect does not take place; and, on the contrary, it seems to possess all the properties of such as are annealed.

Glass is one of those bodies which increase in bulk, on passing from a fluid to a solid state. When it is allowed to crystallize regularly, the particles are so arranged that it has a fibrous texture; but, when a mass of melted glass is suddenly exposed to a cold temperature, the surface crystallizes, and forms a firm shell round the interior fluid parts, by which they become solid, and are prevented from expanding.

By the process of annealing, the glass is preserved for some time in a state approaching to fluidity; the heat increases the bulk of the crystallized part, and renders it so soft, that the internal fibres have an opportunity of expanding and forming a regular crystallization.

A similar process is now used for rendering kettles, and other vessels of cast iron, less brittle; which admits of the same explanation as that above stated. The greater number of metals diminish in bulk when they pass from a fluid to a solid state. Iron, on the contrary, expands.

ANOTTA, ANNOTTO or ARNOTTO, is a dry hard paste, brownish on the outside and red within, brought from Cayenne and various other parts of America, and much used in Europe in dyeing. This article is procured from the seeds of a large tree, the *Bixa Orleana* of Linnæus, *Roucoyer*, or *Macaw* tree, also called by the Caribs *Achiote*, *Cochehue*, or *Bichet*, and by the Brazilians, *Urucu*. They are thus prepared: the seeds when ripe are gathered, the husk taken off, gently bruised and put into a trough to soak for about eight or ten days, being well stirred twice a day with a wooden implement. They are then beaten with heavy mallets for a quarter of an hour, till they are thoroughly bruised, again moistened with water and passed through a sieve. When thus reduced to a kind of pulp, it is put into a wooden vat, and allowed to ferment or putrify for a week, during which time it gives out a very fetid smell, and moulds on the surface. After this the pulp is again beaten, and soaked with water twice successively.

The seed is now nearly exhausted of its colouring matter, which has passed into the several waters with which it has been washed, and which are carefully reserved, strained through sieves, and mixed in different proportions. This water holding the colouring matter suspended, is then transferred into iron boilers, and heated gradually, till a scum rises to the surface, which is successively removed as

it forms into another boiler. This scum is the annotta, and it is slowly dried in the last boiler with perpetual stirring, till it is of so thick a consistence as not to stick to the wetted finger. After this it is laid out on the floor to dry, and made up into cakes, (the negro who does this part of the business smearing his hands with palm oil) and finally wrapped up in palm leaves, and in two months time it is fit for exportation.

The Caribs make annotta in a much simpler manner. They take the seeds when ripe, and rub them for a long time in their hands smeared with palm oil, till the fine red outer coat of the seed is rubbed off and sticks to the palm of the hand, which is the annotta, and undergoes no other preparation than being moulded into large cakes and dried. This is esteemed the purest, as it has undergone no change by fermentation.

Annotta readily dissolves in water, and more easily in alcohol. Its solutions have a yellowish red, or orange cast, and are employed in the countries where it grows for various purposes of colouring, for staining the skin, giving a colour, and a peculiar taste to certain articles of food, sometimes to chocolate. In Europe it is used largely in dyeing, particularly silks and wool, of different hues of red, orange, aurora, &c. In this case it is always prepared with an alkali, which gives a cast of red. The colour is fugitive, particularly in the sun's light, but it is not readily washed out, and is a very powerful dye, a small quantity giving a tinge to a very large body of liquor.

A peculiar use of annotta is in giving the high orange yellow to Cheshire and Wiltshire cheese, so much in fashion at present. To employ it, the annotta is rubbed on a stone with a little whey, till a sufficiently strong solution is made, which is mixed with the cheese-curd just before pressure.

ANTIMONY is a compact brittle metal, of a brilliant slightly bluish-white colour.

Antimony is found in occasional mixture with the ores of lead, of copper, and of silver; but the six following are the only species which are allowed by mineralogists to rank as the proper ores of this metal.

Sp. I. Native Antimony.

The fresh-broken surface of which is of a pure tin-white colour, but by exposure to the air it acquires a slightly greyish or yellowish tinge.

Antimony when native is by no means in a state of absolute purity, but always contains a portion of arsenic, varying from two to fifteen per cent. hence it exhales an alliaceous odour when heated before the blow-pipe.

Sp. II. Grey Sulphuret of Antimony.

This species is divided by the German mineralogists into four varieties, the compact, foliated, radiated and plumose.

Var. 1. Compact.

This variety is rarer than any of the following. It is found mixed with other antimonial ores at Braunsdorf, in Saxony; Goldkronach, in Bareith; Majurka, in Hungary; and in Auvergne: it is usually accompanied by quartz and spathose iron ore.

Var. 2. Foliated.

This variety differs from the preceding in being of a high steel-grey colour, and in presenting a fine grained foliated fracture.

Var. 3. Radiated. (Striated, of Kirwan.)

The recent fracture of this mineral is, like the preceding, of a light steel-grey colour; its surface, however, presents a blackish grey colour, mixed with azure blue, golden yellow, and other iridescent tints. It occurs in mamillated, glandular, and stalactitic masses, or disseminated, or crystallized. The primitive crystalline form of sulphuretted antimony has not yet been ascertained; it is, however, easily and very neatly divisible by sections made parallel to the axes of its prisms. When the striæ are very broad, they give almost a foliated appearance, and being very brilliant, such specimens have obtained the name of *Specular Antimony*. According to the analysis of Bergman, it consists of 74 antimony and 26 sulphur, *per cent.* The Hungarian antimony also contains a variable proportion of gold.

This variety is the commonest of all the antimonial ores. It is procured in Hungary, at Felsobanya, and Kremnitz; at Dravilza, in the Bannat; at Braunsdorf and Rochlitz, in Saxony; at Lubillac, in Auvergne, and at Allemont, in Dauphiné, in France; at Pereta, in Tuscany; in Cornwall, in England; also in Spain, Mexico, and Siberia. The most splendid iridescent specimens come principally from Hungary and Auvergne.

Var. 4. Plumose.

Its colour is steel-grey, passing into greyish black, lead or smoke-grey; by exposure to the air it tarnishes to an iridescent blue or yellow. It has not yet been accurately analysed, but according to Bergman consists of antimony, iron, arsenic, sulphur, and sometimes silver. The proportion of the last ingredient is very variable, never exceeding 4 *per cent.* it is

therefore improperly ranked by some mineralogists among the silver ores.

It is upon the whole a mineral of rare occurrence, and is found chiefly at Freyberg and Braunsdorf, in Saxony; and at Stollberg, in the Hartz; also at Schemnitz, in Hungary. It is accompanied by quartz, calcareous spar, brown spar, galena, martial pyrites, and blende.

Sp. III. Red Antimony.

The colour of this mineral is a cherry red, more or less deep, passing on the surface into brown, reddish, or bluish. Its lustre is little shining, vitreous; its fracture is fine and irregularly fibrous. It is opaque, brittle, almost friable.

No accurate analysis has yet been made of this mineral: it was formerly supposed, on account of its colour, to contain arsenic and sulphuretted antimony; according to Sage it is a native kermes, or hydrosulphuret of antimony: thus much, however, is certain, that it occurs in the crevices and investing the surface of the common grey sulphuret of antimony, and appears to originate from this by the process of spontaneous decomposition: the amorphous or massive variety is frequently studded with octahedrons of native sulphur.

It is found at Braunsdorf, in Saxony; Malazka and Kremnitz, in Hungary; and Allemont, in Dauphiné.

Sp. IV. White Antimony. Muriated A. of Kirwan..

The colour of this mineral varies from snow-white or yellowish white to greyish and ash-grey.

The tabular crystals of this mineral, according to Klaproth, are composed of oxyd of antimony with muriatic acid. The needle-shaped variety from Dauphiné, has been analysed by Vauquelin, and appears to contain

86	oxyd of antimony,
3	oxyd of iron and oxyd of antimony,
8	silex,
97	
3	loss
100	

White antimony is an extremely rare mineral.

Sp. V. Antimonial Ochre.

The colour of this substance is straw or lemon yellow, passing to yellowish grey. It has not yet been analysed, but is supposed by Karsten to be an oxyd of antimony. It occurs in small quantities at Braunsdorf, in Saxony, and in Hungary, mixed with grey and red antimony.

Sp. VI. Yellow antimony.

The colour of this mineral is orange or wax-yellow, or yellowish white, often becoming dusky by exposure to the air. By Rasumousky it is considered as a phosphat of antimony, whereas Born supposed it to be a combination of the muriats of antimony and lead.

The grey sulphuret of antimony is the only ore of this metal which is found in sufficient quantity for the purposes of commerce, and it is fitted for market in the large way by simple fusion. For this purpose the ore being dressed and separated from the greater part of its stony gangue by hand, is placed in the bed of a reverberatory furnace, and covered with charcoal powder; being then brought to a low red heat, the sulphuret of antimony enters into fusion, while the earthy parts float on the surface, and are taken off with a rake or ladle; the fluid portion is then cast into the form of loaves or large cakes, and is fit for sale, forming the *common* or *crude* antimony of the shops. The old method of obtaining crude antimony, and which is still practised in some of the French founderies, was by means of an apparatus consisting of a large crucible, the bottom of which was perforated, and inserted into the wide end of a conical tube, passing through the furnace, and terminating in an earthen pot or reservoir. The crucible was filled with ore broken into small pieces, a cover was luted on, and by the application of a moderate heat, the liquefied antimony dropped through the tube into the reservoir below, while the stony parts were detained in the crucible.

From the crude or sulphuretted antimony thus prepared, there are several methods of separating the sulphur, and procuring the metal in a state of purity; the best, and which is the most used in processes in the great way, is the following.

Reduce the sulphuret to small pieces, and strew it evenly and thinly on the floor of a reverberatory furnace, in order to drive off the sulphur by roasting. The heat at first must be very gentle, scarcely exceeding that required for the fusion of tin, otherwise the antimony will clog or even melt: in a short time a lambent blue flame, proceeding from the combustion of the sulphur, will appear over the surface of the ore, which, at the same time, will begin to lose its metallic lustre, and be converted into a greyish oxyd. By assiduously stirring the ore, and cautiously increasing the temperature as its fusibility decreases, it will, in the course of some hours, cease to emit sulphureous vapours, and bear a moderate red heat without

melting. The roasting is now finished, and when the ore is removed from the fire, and becomes cool, it will be found converted into an ash-grey oxyd, weighing from thirty to thirty-six per cent. less than the original sulphuret, and still by no means entirely free from sulphur. In order to obtain the regulus from this grey oxyd, it is to be mixed with half its weight of crude tartar, and exposed to a full red heat in a covered crucible. The carbonaceous part of the tartar decomposes the oxyd, and the antimony, reduced to the metallic form, collects itself in a mass at the bottom of the crucible, except a variable proportion, which is held in solution by the sulphuret of potash formed by the alkaline base of the tartar and the sulphur of the oxyd. The quantity of metal thus obtained in the large way, equals from 66 to 70 per cent. of the oxyd employed; but a much greater loss will be observed, if the ore has not been properly roasted. The method followed by T. Kunkel appears, however, on the whole, to be better and more economical than the common practice. He mixes the roasted oxyd with oil or fat, and a little powdered charcoal, puts the mass into a crucible to melt, and as soon as the regulus begins to show itself, injects, by degrees, some powdered nitre, in the proportion of an ounce to a pound of oxyd: the matter soon appears in thin fusion, and on being poured out affords a pure regulus, in considerably greater proportion than is obtainable by the usual way of operating.

The expence of nitre and tartar in preparing regulus of antimony in large quantities, for the purpose of commerce, is very considerable; in consequence of which a series of experiments were undertaken by Hassenfratz, Vauquelin, and Bouillon la Grange, in order to ascertain whether the use of these substances could be superseded by cheaper materials. In the prosecution of this enquiry, different portions of the roasted ore were mixed with charcoal powder, with tallow, and with pitch, and exposed in covered crucibles to a heat sufficient for their reduction: the crucibles being then withdrawn were found to contain only a little carbonaceous matter, and a few minute globules of antimony, all the rest being evaporated. Some grey oxyd was then mixed with 1st. two parts of lime and one of clay; 2d. equal parts of sulphat of barytes, chalk and clay; 3d. with common salt; 4th. with sulphat of soda: and the materials being strongly heated, were all found converted into yellow glasses, without any appearance of regulus. These being each pulverized, and mixed with charcoal powder, were again heated as before, and produced only vitreous scoriæ, with a few minute globules of antimony. Lastly, some of the same grey oxyd being fluxed with half its weight of tartar, yielded a perfect button of pure antimony. Hence it appears that potash (and probably the fixed alkalies in general) exert some specific action on antimonial oxyd, which renders it much more fixed while converting into regulus, than when mere carbonaceous or even vitrescent fluxes are made use of.

The most expeditious, though at the same time the most expensive and inaccurate manner of procuring the regulus of antimony, is by *scorification.* For this purpose eight parts of the grey sulphuret are reduced to a fine powder, and mingled with six parts of tartar and three of nitre. The mixture is projected gradually into a red hot crucible, till it is nearly filled, a slight detonation taking place at each successive projection: the crucible is now closed with its cover, and a brisk heat being applied for nearly half an hour, the contents are either suffered to cool in the crucible or are poured into a greased and heated iron cone. The upper part of the mass consists of alkaline scoriæ, holding in solution a portion of antimonial oxyd, beneath which is a button of pure antimony, weighing between three and four eighths of the original sulphuret. Some advise that the nitre and tartar should be detonated together before the crude antimony is added; but this is decidedly an injudicious way of proceeding, the use of the nitre being not to alkalize the tartar but to oxygenate the sulphur; hence it is probable that the yield of regulus would be increased by first detonating together the nitre and sulphuret, and not adding the tartar till towards the end of the process.

An excess of nitre or tartar, or both, is carefully to be avoided, as it not only enhances the expence but diminishes the produce. Lemery found that sixteen ounces of sulphuretted antimony, mixed with an equal weight of nitre, and the same of tartar, yielded only five ounces and a half of regulus; whereas sixteen ounces of sulphuret, twelve ounces of tartar, and six ounces of nitre, afforded six ounces and one dram of regulus.

There is yet another way of separating the regulus of antimony from the sulphur with which it is naturally combined, by taking advantage of the superior affinity for sulphur which other metals possess over antimony. There are five metallic substances capable of decomposing crude antimony with greater or less accuracy, by being fused together with it; these are

iron, copper, lead, silver, and tin; only the former is at present, however, made use of, as it is both cheaper and more effectual than any of the rest. The antimony procured by this method was called by the old chemists *Martial regulus*, on account of the use of iron in its preparation, a name which may very properly be retained, as it is impossible by any other means than solution in acids to render this regulus absolutely free from iron: in strictness, therefore, it ought to be considered as antimony alloyed with a small and variable proportion of iron. In order to prepare the martial regulus as free from iron as possible, the following method, recommended by Lemery and Beaumé, appears upon the whole to be the best. Take eight ounces of horse-shoe nails, and heat them in a crucible almost to whiteness; then add sixteen ounces of coarsely pounded crude antimony; cover the crucible and keep up the fire; in a few minutes the whole will be melted; at which time add by degrees three ounces of nitre: after a slight detonation has taken place, and the whole is brought to a state of perfect fusion, pour it into an iron cone, previously heated and greased, and strike the sides of it gently as the mass becomes solid, to favour the precipitation of the regulus. When cold it will be found to consist of a mass of antimony, weighing about ten ounces, covered by an alkaline ferruginous scoria, from which it may be readily separated by a blow with a hammer. The regulus, however, still contains not only iron but sulphur; it must therefore be remelted, and two ounces of crude antimony, and three ounces of nitre are then to be added; when all detonation has ceased, pour it into a cone as before, and separate the regulus from the scoriæ. Remelt the regulus, and project upon it three ounces of nitre, then separate this purified regulus from the scoriæ, and once more melt it with a strong and rapid heat; project upon it, by degrees, three ounces of nitre, and immediately after pour it into a cone: there will be obtained about eight ounces of a beautiful stellated regulus, covered with yellowish white scoriæ. In this process the materials employed are, eighteen ounces of sulphuret, eight ounces of nails, and twelve ounces of nitre; four separate fusions are required, and the product is eight ounces of regulus.

The martial regulus may be procured in a more expeditious way, though not so free from iron, by bringing five ounces of horse-shoe nails to a white heat in a crucible, and then adding sixteen ounces of crude antimony: as soon as the whole is in very liquid fusion, project, at several times, one ounce of pulverized nitre; when the detonation has entirely ceased, put on the cover of the crucible, raise the heat for a few minutes, then remove the crucible from the furnace, and allow it to cool very gradually; there will be found beneath the scoriæ about seven ounces of regulus.

Perfectly pure antimony, whether procured by roasting or scorification, is a metal of a dusky white colour, between that of tin and iron, and exhibits, when recently broken, a remarkable degree of brilliancy: it is entirely destitute of ductility, and may, without much difficulty, be reduced by trituration to a fine powder; it is moderately hard, yielding easily to a common knife: its fusibility is rather less than that of zinc, as it requires a low red heat to be kept in a liquid state. Antimony unites with gold, platina, silver, copper, iron, mercury, tin, and lead, forming alloys, if we except the two last, of little importance.

Antimony and tin being mixed in equal proportions, form a moderately hard, brittle, and very brilliant alloy, capable of receiving an exquisite polish, and not easily tarnished by exposure to the air; it has been occasionally manufactured into speculums for telescopes.

Antimony and Lead. Gmelin found that equal parts of these two metals produced a porous brittle alloy; one part antimony and two lead gave a homogeneous metal much harder than lead, but ductile under the hammer: one part antimony and eight lead formed an alloy more fusible, harder, and whiter than lead without impairing its ductility. According to Gellert, 386 grains of lead and 333 of antimony afforded a brittle alloy, with a granular somewhat shining fracture, whose specific gravity was greater than the mean of its constituent parts. Antimony, lead, and a little copper, form type-metal.

APPLETREE, APRICOT. } See HORTICULTURE.

AQUEDUCT, an artificial channel, made for conveying water from one place to another, without employing any other mechanical principle than this, that a body will descend along an inclined plane, or from a higher to a lower level. Hence it is almost unnecessary to observe, that an aquæduct must have a continued slope from its source to the place for which the water is destined. If there is not a sufficient natural source, the supply must be increased by artificial cuts or drains; and the water may also be augmented in

its course from contiguous springs, by means of cuts branching out from points in the sides of the aqueduct.

It may sometimes be expedient to conduct it in a circuitous direction, in order to lessen the expense and obtain more abundant collections of water either from springs or artificial excavations, than would result by conducting it in a more direct course. To receive such supplies in the most effectual manner, the channel should be left without any building. In that state, however, it is liable to be worn by the action of the current, the course of which is at last obstructed by accumulations of sand, mud, &c. in particular places; though frequency of repairs, in such cases may be diminished, by making at intervals large pits in which the sand and mud may be deposited.

If the collection at the source is so great as to render all further supplies unnecessary, the channel should then be well built of stone or brick, and if it is also wished to be free from rain water, which often having fallen would run into the channel frequently in a muddy state, the aquaeduct must be covered above. If it can not be conducted round a valley at less expense than across, the valley must be built up: the building will answer best in the form of an arch or a succession of arches, and indeed in most cases it is absolutely necessary to construct it in that manner, particularly when the valley has a river running through it. It is chiefly in this construction of the arches that the ancient aque ducts excite our astonishment. When the valley is deep several rows of arches may be made one above another.

When it is necessary to pass a mountain, the aqueduct may either be carried round it or through it by a large perforation. In such cases it is easy to see that the construction of aquaeducts must be attended with enormous expense; and in modern times, instead of allowing the water to flow in an open channel, it is found more economical to employ the hydrdulical principle; that, however, the channel may rise or fall, water will continue to run in it, provided it be enclosed on all sides, and no where carried higher than the source. It will however be remembered, when water is to be conveyed in any considerable quantity, and the ground over which it is to pass is not much interrupted by hills and vallies, that an aqueduct from a combination of circumstances is to be preferred. The Romans were either ignorant of this principle, or thought that pipes would not afford a sufficient supply of water for all the purposes they had in view. The quantity of this necessary article of life for the table as well as for baths and fish ponds, gave rise to aqueducts of astonishing grandeur and magnificence, to which even emperors were proud to attach their names. Three of these still exist and supply with water the inhabitants of modern Rome. The remains of aqueducts may be traced in other parts of the world; one of the most splendid of these is that of Segovia in Spain, of which 159 arches joined without mortar still remain to attest its ancient grandeur. The most considerable aquaeduct of modern times, is that which was built near Maintenon by Louis XIV. for conveying to Versailles the waters of the river Eure. Its length is 7000 fathoms, its height 2560, and the number of its arches 242, arranged in three stories.

There are few cities in the world better situated to receive a supply of water through the means of an aqueduct than Philadelphia, if, for the purpose of passing the water over some deep vallies, it be combined with hydraulics: that however, these advantages will be adopted appears doubtful, at least till by experience they become better appreciated. On the whole, we think where a constant supply of water can be obtained, and the ground for the conveyance of the water is tolerably even, an union of the aqueduct with pipes is by far the most durable and least expensive plan of supplying large cities with this necessary article. See Water Works.

AQUA-FORTIS, is a nitrous acid of a certain strength; when concentrated and smoaking, it is called spirit of nitre. The Aqua-fortis used by dyers, brass-founders, &c. is not only weaker than spirit of nitre, but contains about one half water and sometimes a portion of vitriolic acid. It may be made, by distilling crude nitre with calcined vitriol, equal parts; or with somewhat more than half its weight, of oil of vitriol; or by mixing one part of oil of vitriol, with nine parts of pure spirit of nitre.

AQUA-TINTA. See Engraving.

ARABLE LAND. See Agriculture.

ARCHILLA See Orchella (*Litmus*)

ARGENTUM MOSAICUM. This is a metallic alloy in the form of silvery flakes, used as a pigment for giving a white metallic lustre to plaster casts, paper, porcelain, &c.

It is prepared in the following manner. Take an ounce and a half of grain tin, and the same quantity of bismuth, melt them together in a clean crucible, and

stir the mass repeatedly with a clean iron rod till the two metals are accurately mixed. Then remove the crucible from the fire, and when its contents are upon the point of becoming solid, pour in an ounce and a half of warmed quicksilver, stirring it as before. Previously to using this alloy, it must be ground in a stone or earthenware mortar with white of egg and spirit varnish, and in this state applied to the intended work. When dried it may be burnished in the usual manner, and has then very much the appearance of silver.

ARGOL, or TARTAR, is a substance thrown off from wine, after it is put into casks to depurate. The more tartar is separated, the more smooth and palatable is the wine. This substance forms a thick hard crust on the sides of the casks: and as part of the fine dregs of the wine adhere to it, the tartar of the white wines is of a greyish white colour, called white argol; and that of red wine has a red colour, and is called red argol.

When separated from the cask in which it is formed, argol is mixed with much heterogeneous matter; from which, for the purposes of medicine and chemistry, it requires to be purified. This purification consists in first boiling the Argolin water, filtrating the solution, and allowing the salt to crystallize, which it very soon does, as it requires nearly twenty times its weight of water to dissolve it. The crystals of tartar obtained by this operation, are far from being perfectly pure; and therefore they are again boiled in water, with an addition of clay, which absorbs the colouring matter; and thus on a second crystallization, a very pure and white salt is obtained. These crystals are called *Cream of Tartar*, and are commonly sold under that name.

Cream of Tartar may be recomposed in the following manner; upon fixed vegetable alkali pour a solution of the acid of tartar; and continue this, till the effervescence is over. The fluid will then be transparent; but if more of the acid is added, it will become turbid and white, and small crystals like white sand will be formed in it. These crystals are a perfect Cream of Tartar. Argol therefore consists of fixed vegetable alkali, over saturated with the pure acid of tartar, and joined by a great deal of earthy impurities and colouring matter.

The white Argol is preferable to the red, as containing less of the drossy or earthy matter. The marks of good argol of either kind, are its being thick, brittle, hard, brilliant, and little earthy. That brought from Germany is the best, on account of its being taken out of those great tuns, wherein the salt has time to come to its consistence.

Argol is of considerable use among dyers, as serving to dispose the stuffs to take their colours the better.

ARMENIAN BOLE, is a soft bole of red colour, used in medicine. An indurated kind of this affords the material for the red pencils.

Bolus's or boles, are martial clays, containing a fine and dense clay of various colours, with a large quantity of iron.

The Armenian Bole was formerly brought from Armenia, but it is now found also in several parts of France and Germany.

ARMENIAN STONE. This substance is improperly called a stone, being nothing else than an ocherous earth, and properly called *Blue Ochre.* It is a very valuable substance in painting, being a bright and lively blue. It easily breaks between the fingers, and does not stain the hands. It is of a brackish disagreeable taste, and effervesces with acids. It is a very scarce fossile, and was in so high esteem as a paint amongst the ancients, that counterfeits were continually attempted to serve in its place.

Though in but small quantities, it is found very pure in the mines of Gosslar in Saxony.

ARRACK, Arac, or Rack, is a spirituous liquor imported from the East Indies, and used either as a cordial, or an ingredient in punch. It is obtained by distillation from rice, or sugar, fermented with the juice of cocoa-nuts. Goa and Batavia are the chief places from which arrack is exported. At the former, there are three sorts, viz. the single, double, and treble distilled. The double is but a weak spirit, in comparison with that obtained at the latter place; but, on account of its peculiar flavour, it is preferred to all the others.

The arrack now in general use contains but a sixth, and sometimes only an eighth part of alcohol, or pure spirit. A spirituous liquor of this name is also extracted by the Tartars of Tungusia, from mare's milk, which is first suffered to turn sour, and then distilled two or three times, between two close earthen pots, from which it runs through a small wooden pipe. It is possessed of the most intoxicating qualities; so that, according to Professor PALLAS, men, women, and children, frequently drink themselves into a semi-delirious trance, which continues for forty-eight hours.

Genuine arrack is said to possess balsamic, softening, and restorative properties, and to be less liable to produce the usual inconveniencies of other spirits. It

is farther supposed to contain a fine subtile oil, so minute as to incorporate readily with water: hence it is generally preferred in those cases, where repeated debauches have abraded the internal sides of the vessels. Persons who are unfortunately addicted to the use of ardent spirits, as well as those troubled with the gout or rheumatism, and who cannot comply with the rules of sobriety and temperance *may* use arrack in preference to Hollands, or brandy. On account of its strong empyreumatic oil, however, it is difficult of digestion, soon turns rancid, causes numerous obstructions, and is consequently injurious to individuals of lax solids, and thick or sizy fluids.

ARROW-GRASS, is a plant frequently met with in marshy grounds, or near the sea coast, and in saline tracts. As they are eaten with avidity by sheep, for which they serve as an excellent and wholesome food, we presume strongly to recommend their culture. An additional motive for the propagation of the arrow-grass, may be suggested to the farmer and breeder of sheep; because it thrives extremely well in moist and swampy places, where few other vegetables would grow.

ARROW-HEAD, COMMON, is one of those neglected plants, which, though growing wild in many parts of the United States, especially on the banks of rivers are not converted to any useful purpose: The root of the arrow-head is composed of numerous strong fibres, which strike into the mud; the foot stalks of the leaves are of a length proportionate to the depth of the water in which they grow; they are thick, fungous, and sometimes three feet high. Its sharp pointed leaves resemble the point of an arrow, and float upon the water. At the lower extremity of the root, there is always, even in its wild state, a bulb which grows in the solid clay, beneath the muddy stratum.

This *esculent* root is industriously cultivated in China and America, where it attains to the size of several inches in diameter. With respect to the manner of dressing and preparing such vegetables, we shall give the necessary directions under the article BREAD.

The arrow-head requires a low, cold, marshy situation, and a clayey soil, where scarcely any other plant would thrive. Here it grows luxuriantly, and produces an oblong, thick, bulbous root, which, from its *mealy* nature, may be easily converted into starch, or flour. Even in its raw and unprepared state, it affords a proper and wholesome food for horses, goats and hogs; though cows do not relish it—There are two methods of propagating this beneficial plant; either by the wild-growing fibres of the root, or by the seed; and we earnestly recommend its culture, from a conviction of its great utility.

ARROW ROOT, Indian, or the *Maranta*, a plant of which there are three species, the *arundinacea, galanga,* and *comosa;* all of them are herbaceous, perennial exotics of the Indies, and kept in our hot-houses merely for curiosity. The first of these species is the true *starch-plant,* and is likewise used by the Indians to extract the poison communicated by their arrows.

Dr. WRIGHT, of Jamaica, appears to be the first who informed us that a decoction of the fresh roots makes an excellent ptisan in acute diseases. From an ingenious pamphlet published in 1796, by Mr. T. RYDER, of Oxford-street, we farther learn, that one of his West-Indian patients, employed it as an article of diet, and since that period it has been very generally used in families.

The arrow-root powder unquestionably yields a larger proportion of nutritive mucilage than any European vegetable, if we except the *Salep-root;* hence a single tablespoonful of either, makes a pint of strong and nourishing jelly, which affords a very proper food in acute diseases as well as in all those complaints where animal food must be abstained from.

Mr. RYDER, before mentioned, has justly recommended the culture of this root to the West-Indian Planters, and the new African Colonists, as an object of commerce, and the most eligible substitute for starch, made of wheat: 1. Because it would save annually 66,000 quarters of that valuable grain, in Great Britain alone, where the average quantum of starch made in the years 1793, 1794, and 1795, amounted to 8 millions of pounds weight, allowing one hundred and twenty pounds per quarter:—2. As the wholesale price of the arrow-root was, in 1796, fifteen pence a pound, and as one pound of its starch is equal to two pounds and a half prepared from wheat, its intrinsic value would, by this computation, not exceed *six*-pence per pound: whereas the average price of starch in England for seven years (from 1789 to 1795) may be stated at *nine*-pence the pound. 3. As the arrow-root contains more soluble, gelatinous matter, occupying less space, being less enveloped in earthy particles and affording a purer farina than any other plant, it may be reasonably inferred, that the starch obtained from it must be of the finest quality: an opinion amply confirmed by three clearstarchers, who were, on this occasion, consulted by the Society

for the Encouragement of Arts, Manufactures and Commerce.

The plants would thrive in the southern states, and ought to be introduced into them, by some of the numerous Americans who visit the West-Indies.

ARSENIC, is a substance of very frequent occurrence, being found in combination with almost every other metal, as well as with sulphur and lime: the four following species however, are the only ones that by the common consent of mineralogists are ranked as ores of this metal, the rest being considered as arsenicated ores of silver, copper, cobalt, &c.

Sp. 1. Native Arsenic.

The colour of this mineral when newly broken, is a light lead-gray, passing into tin-white; but the surface by exposure to the air becomes yellow, then blackish gray, and at length almost black.

Native arsenic has not been accurately analysed; but besides arsenic, it appears always to contain a little iron, to which its fusibility is owing, and occasionally a very small portion of gold or silver.

This mineral is found only in the veins of primitive mountains, accompanied by red silver, realgar, galena, specular cobalt, kupfernickel, pyrites, &c. It occurs in the mines of Freyberg, in Saxony; at Geisberg, in Carinthia; at Nagyag, in Transylvania; and Saint Marie aux Mines, in France.

Sp. 2. Arsenical pyrites, Marcasite, or Mispickel.

The colour of this mineral, when recently broken, is a silvery white, but it soon tarnishes to yellowish, grayish, bluish, or iridescent.

This mineral has not been accurately analysed, or rather appears to contain arsenic, iron, and sulphur, in variable proportions; mixed with which is occasionally found from one to ten per cent. of silver.

It is found in almost all metalliferous primitive mountains; but the variety containing silver has hitherto been met with only at Freyberg and Braunsdorf, in Saxony.

Sp. 3. Sulphuret of Arsenic.

This species is generally, though perhaps unnecessarily, divided into two varieties.

Var. 1. Realgar; the colour of which is a bright aurora red, passing on one side into scarlet, on the other to light orange. It has never been accurately analysed, but consists for the most part of arsenic and sulphur.

Realgar occurs native in the vicinity of Etna and other volcanoes, and in the primitive mountains of Germany, Swisserland and Hungary. The substances by which it is usually accompanied are native arsenic, red silver, and galena.

Var. 2. Orpiment.

Orpiment differs from realgar in the following particulars. Its colour is a bright lemon yellow, passing into gold yellow and aurora-red.

Sp. 4. Native White Arsenic.

Its colour is snow white, or yellowish reddish, or smoke gray.

This mineral is of very rare occurrence, having been met with as yet only in the cobalt mines of Bohemia and Saxony, and on the surface of native arsenic in Transylvania and Hungary.

White Arsenic, when in its purest state, appears as a beautiful white, sonorous, vitriform mass, very brittle, and easily reduced to powder. When recently prepared it is considerably transparent, but becomes opaque by keeping. It is prepared in the large way by a second sublimation of the impure arsenic, obtained in the roasting of the arsenical ores. M. Fragoso de Sigueira gives the following account of the method adopted in Bohemia.

The subliming vessels are strong square boxes of cast iron, furnished with conical heads of the same material, closely luted to them with clay. The square boxes are disposed in a large brick area, which is heated by the flues of two furnaces placed a little below them. When red-hot, the impure arsenic is laded into the boxes by fifteen pounds at a time, where it melts, and in about an hour after it begins to sublime into the conical head. When no more rises, another fifteen pounds is put into the vessel, and treated as before; and this successive addition is continued till about 150 pounds of arsenic have been used to each vessel, the sublimation of the whole of which quantity lasts about twelve hours. When cold, the workmen take off the conical head, and carry it with its contents to another place, where they break off with hammers the sublimed arsenic, separating any impurity for a second operation.

The yellow glass of arsenic, or artificial orpiment, is prepared in the same manner with the same apparatus, but for this the arsenic is previously mixed with half its weight of sulphur. In either case the heat should be maintained all the while uniformly red, so as to keep the materials in the lower vessel always in fusion. When these are tolerably pure,

almost the whole rises in the sublimation.

The rough material of this process is the oxyd of arsenic, obtained by roasting the TIN and COBALT ores, and twice torrefied before it is used for sublimation. If these precautions are not observed, the arsenic remains yellow and gray instead of white.

Regulus of Arsenic, or *Arsenic*, properly so called, may be prepared in several ways, and the most convenient substance for procuring it is the common white arsenic of the shops. This is a simple oxyd of the metal, and it may be reduced by heating with any carbonaceous matter; but as arsenic in a metallic state is even more volatile than its oxyd, the common mode of fusion will not answer, as the metal will escape in dense fumes as fast as it is produced. Sublimation must therefore be used, the white arsenic and its reducing flux being heated together in close vessels, and the fumes of the reguline arsenic being condensed on a cooler part of the same or of an adjoining vessel. The following mode is simple, easily performed, and makes an interesting experiment in the small way. Mix white arsenic with oil into a mass of the consistence of soft dough, drop it into a dry Florence flask, taking care not to soil the neck as the mixture passes down; put the vessel on charcoal, either naked or in a sand pot, and heat gradually. When hot enough, the oil begins to burn, and partly flies off in thick fumes, blackening the neck of the flask; these fumes soon acquire a strong and most offensive odour, somewhat like garlick, owing to the escape of part of the arsenic, which should be carefully avoided by the operator. The whole flask now becomes obscure, so that the process can only be judged of by the copiousness of the fumes, which presently are seen to deposit black films on the neck of the flask, like soot, but symmetrically arranged. The heat should be slowly raised, so as to redden the bottom of the flask, and when the fumes scarcely arise, and the hottest part of the vessel is found to be nearly empty, the whole may be allowed to cool. On breaking the vessel carefully, nothing is found in the bottom, as far as it was red-hot, but a light spongy coal, the remains of the oil; all above it, to the very top of the neck of the flask, is lined with a light black-gray crust, beneath which, immediately adhering to the glass and taking the impression of its shape, is a brittle black shining metallic substance, which is the regulus of arsenic. The neck of the flask is also covered with a number of beautiful greenish transparent pyramidical crystals of arsenic, oxydated by the access of air through the mouth, which, in condensing, assume this elegant form. To obtain the regulus more completely, the whole of the contents of the flask should be mixed together by rubbing, and put into a fresh flask without addition, and again sublimed slowly, stopping the mouth with paper, as there is now little need of giving vent to any fumes during the process. The sublimed regulus is now as perfect as it can be obtained, often crystallized, and exhibits every mark of a true metal.

The old method of preparing this metal was the following. White arsenic four parts, black flux two parts, iron filings and borax each one part, were put into a covered crucible, and hastily fused; after which the vessel was immediately removed from the fire. Much of the arsenic was dissipated in this way, but at the bottom of the crucible a blueish white regulus was found, consisting of reguline arsenic, combined with the iron into a hard alloy, the use of the latter metal being only to detain the arsenic and prevent its volatilization.

This alloy tarnishes much sooner than the pure regulus. By sublimation in close vessels, the arsenic rises much sooner than before, but is thought still to carry up with it a small portion of iron, though the greater part is left behind.

For the most delicate chemical purposes, a beautiful regulus may be made by mixing arseniat of potash with about one-eighth of charcoal, and subliming in a close glass vessel slowly heated to redness. The regulus is beautifully brilliant and crystallized.

The regulus is equally prepared in the large way by sublimation, in earthen vessels, of the oxyd, mixed with a reducing flux.

Arsenic when pure has the following properties: its colour is between a tin-white and lead-blue, which by exposure to air readily tarnishes, the later as it is the purer, and becomes first yellow, and then black and pulverulent; but it may be kept under water unaltered. Slowly sublimed in close vessels, it crystallizes in octahedrons. Its hardness is about equal to that of copper, but it is quite brittle and very easily pulverizable. Of all metals arsenic is the most volatile by heat, for it begins to rise in fumes at about 356° Fahrenheit, that is, long before it melts, so that it can hardly ever be seen in a state of fusion. These fumes in the open air are dense, white, and exhale a very peculiar and noxious smell,

somewhat resembling garlick, which circumstance forms one of the readiest tests for this metal or its oxyd. Arsenic suddenly heated to redness, by being thrown into a very hot crucible, takes fire, and burns with a whitish-blue flame, yellow at the edges.

The condensed fume of arsenic heated in close vessels is the regulus unaltered, but in the open air it condenses into a white, sometimes yellowish, mealy substance, which is the *White Oxyd of Arsenic*, similar to the common *white arsenic* of the shops. This oxyd is also volatile *per se*, but requires for the purpose a greater heat than the reguline arsenic, and when mixed with earthy substances it acquires so much fixity as to prove a most powerful flux.

This semi-metallic concrete is very usefully employed in various branches of the arts and manufactures; it is frequently added as an ingredient, to facilitate the fusion of glass, and to produce a certain degree of opacity. Painters use two arsenical preparations, namely, the orpiment and realgar. A very beautiful green pigment may be precipitated from blue vitriol, by a watery solution of white arsenic and vegetable alkali: this, when prepared either with water or oil, affords a permanent colour. (See Colour Making.) It is highly probable that, if arsenic were added to the paint used for wood, it might form an ingredient which would not be liable to be preyed upon by worms. But the practice of painting the toys of children with arsenical pigments, deserves severe censure; as they are accustomed to put every thing into their mouth.

In dyeing, it is likewise of great service. Combined with sulphur, it has the property of readily dissolving indigo; for which purpose it is used in the printing of calico, and other cloth. On exposure to the air, however, the arsenic is precipitated from this solution, and may be farther employed in pencil colours. Some dyers are said to understand the art of imparting beautiful shades of colours to furs, by arsenical solutions. See Dyeing.

In rural and domestic economy, this concrete is also frequently resorted to with great advantage, though not always with due precaution. Farmers dissolve it in lime-water, for steeping wheat, in order to prevent the smut; and it is likewise asserted, that the husbandmen of Flanders and Germany use it for fertilizing the earth, by sprinkling the soil with a solution of arsenic in dung-water. See Agriculture.

Arsenic is one of the most sudden and violent poisons we are acquainted with. Its fumes are so deleterious to the lungs, that artists ought to be extremely cautious to preserve themselves from its influence on their mouth and nostrils, as well as from touching it with their hands; for every external contact may be attended with serious consequences. Hence they should dress in thick and firm clothes, keep at a proper distance from the exhaling fumes, and cover the orifices of the face with a mask, made for the purpose. In their system of diet, we advise them to make use of a great proportion of bland and mucilaginous nourishment; such as fresh butter, pork, sweet-oil, milk, artichokes, and similar vegetables.

ARSENIC ACID. We are indebted to the admirable skill and sagacity of Scheele for our first knowledge of this acid, and of most of its known combinations. To prepare it, put 2 ounces of white arsenic into a retort, with 7 ounces of muriatic acid, and dissolve the arsenic by boiling: then, when still hot, add 3½ ounces of pure nitrous acid, and again heat. The mixture soon foams, and red nitrous vapour escapes. When this last appearance has ceased, add another ounce of white arsenic, dissolve by boiling as before, and then add 1½ ounce additional of nitrous acid, whereby the same ebullition and escape of red vapour will be renewed. Distil the whole to dryness, till a white mass remains in the retort, which should be gradually heated to redness. When the retort is cold, break it, and the dry substance within is the *concrete acid of arsenic*, which is transparent when hot, but on cooling becomes white and opaque. Dissolved in water, it forms a strong acid liquor, leaving behind some siliceous earth, acquired from the retort, which is much corroded in the process. The concrete acid also deliquesces by keeping in a moist place, and runs into the same acid liquor.

In the above process, the use of the muriatic acid is to keep the arsenic dissolved whilst the nitrous acidifies it. If economy of the distilled nitro-muriatic acid be no object, the second addition of white arsenic and nitric acid may be spared, and the whole taken at once: that is, 3 parts of white oxyd, dissolved in 7 parts of muriatic acid, and 5 parts of nitric acid, added when the solution is effected. Towards the end, when the arsenic acid is nearly dry, the expulsion of the last-adhering portion of nitric acid is attended with a boiling up, which is apt to carry with it part of the acid of arse-

nic, and thus an error arises in estimating the quantity produced. To prevent it, Proust gently shakes the retort at this period with a rotatory motion, which much promotes the easy volatilization of the nitrous acid, prevents the ebullition, and the metallic acid thickens immediately. In applying the red heat to dry it thoroughly, it should be continued till a few crystalline streaks of sublimed oxyd of arsenic appear in the top of the retort; that is, till the acid begins to be spontaneously decomposed by heat. It is then quite pure.

A speedier way of preparing this acid is the following: mix together in a crucible 2 parts of muriatic acid of 1.2 specific gravity, 8 parts of white oxyd of arsenic, and 24 parts of nitric acid of 1.25 specific gravity. Evaporate to dryness, and expose the mass to a slight red heat. The quantity of the acids recommended varies considerably, but no harm can ensue from using an excess of them, beyond the loss of acid; and on the other hand, if too little be employed for acidifying all the arsenic, it is probable that all the imperfectly oxidated portion will fly off in the heat, and the arsenic acid left behind will be equally pure.

Arsenic acid has but little taste till previously dissolved in water, when it is extremely sour. Its specific gravity when dry is about 3.391.

According to Proust, and other confirming calculations, 100 parts of arsenic in the metallic state acquire 33 of oxygen when converted into the white oxyd, and 20 additional oxygen when completely acidified. So that 100 parts of the white oxyd are composed of about 75 of arsenic and 25 of oxygen; and 100 parts of the acid contain 65.4 of arsenic and 34.6 of oxygen.

The compounds of arsenic with *sulphur* merit attention. Both the regulus and white oxyd unite readily with sulphur, and the result is an amorphous mass, of a fine yellow or red, according to the proportions, called in the former case *yellow arsenic*, in the latter *sandarac* or *realgar*. Similar combinations are also found native. The exact proportions of each vary according to circumstances, and it is not precisely determined whether the colour is more owing to these proportions or to the degree of oxygenation of the arsenic. They are given however in the best authors to be, in the *red* sulphuret 1 of sulphur to 4 of arsenic, and in the *yellow* 1 to 9 or 10. Sulphur renders arsenic much more fixed in the fire, so that the red sulphuret may be melted by moderate heat into a transparent mass, called *arsenical ruby*. In the large way these sulphurets are prepared as pigments, and the exact process is not generally known, but it is said to be by subliming in earthen vessels iron pyrites mixed with mispickel or some of the other native ores of arsenic and iron. The iron is certainly of great service is diminishing the volatility both of the arsenic and the sulphur, for a full red heat is requisite to drive them off; and we find in the way of experiment, that a simple mixture of white arsenic and flowers of sulphur sublime too hastily to contract a very close union, and seldom produce an orpiment of a full uniform body of colour. See Colour Making.

For experiment, the operation may be performed in a glass matrass, slightly stopped at the mouth, and heated only at the bottom gradually to redness. Equal parts of white arsenic and sulphur well mixed, yield in this manner a red sublimate, which attaches itself to the neck of the vessel. If two parts of arseniat of potash and one of sulphur, are slowly heated, barely red, for an hour in a matrass, a very fine realgar of red sulphuret sublimes, and the residue at bottom consists of a yellow orpiment, mixed with *liver of arsenic*, or arsenic united with potash. The arsenic acid gives also a fine realgar. Six parts of liquid arsenic acid mixed with one of sulphur, give no signs of mutual action till the water is expelled, when, on encreasing the heat, the whole rises rapidly, and forms a fine red sublimate of realgar. The dry arsenic acid and sulphur, in equal parts, heated for an hour, give the same products.

Quick-lime and orpiment boiled together produce a sulphuret of lime, holding some arsenic in solution. This has long been known as infallible to cause the hair to fall off where it is rubbed, and is also used as a *wine-test* to detect the presence of lead, which it does by making a black precipitate. See Tests.

The great volatility of arsenic, either reguline or oxidated when heated, renders it difficult to unite it by fusion with the metals that cannot themselves be melted with less than a red heat. There are two or three ways however of managing this combination. One is by first bringing the metal into fusion, then throwing in the crucible the arsenic, hastily mixing them, and cooling the alloy speedily, before much of the arsenic has had time to evaporate. Some artists in this way unite arsenic and copper, by melting the copper, wrapping up the arsenic in paper, and thrusting it with hot pincers to the bottom of the melted metal, through which it immediately rises

and diffuses itself pretty uniformly. Another method is to mix the white oxyd of arsenic with charcoal, and put it at the bottom of a tall crucible, over this to spread a layer of clay, and above the clay to strew the filings of the metal, with which the arsenic is to be alloyed. By heating the crucible, the arsenical oxyd becomes reduced by the charcoal, sublimes in the metallic state through the clay, and unites with the heated metal above, fusing it down, in proportion as the alloy becomes saturated with arsenic. A third method, and the most convenient, is to employ the white oxyd of arsenic, and to mix it with an alkali (with or without a carbonaceous flux) and heat it with the metal. Soap is a very good addition in this case, as it furnishes the arsenical oxyd with both carbon from its oil, and with alkali. The latter keeps down the arsenic and renders it much more fixed in the fire, as has been before mentioned in describing the combination of these two substances. When no carbonaceous matter is present, the arsenical oxyd becomes reduced at the expence of part of the other metal, which therefore is found partly oxidated, and separates from the alloy uniting with the alkali into a scoria.

Those of the arsenical alloys which are used in the arts, such as *White Copper*, the *Lead* alloy for shot, arsenicated *Platina*, &c. will be mentioned under these metals.

Arsenic is one of the least valuable of the metallic substances. Its violent effects on the animal body when taken internally, and the easy solubility of its oxyds in almost every fluid, render it always suspicious, and often highly dangerous, when employed in the arts. The white oxyd or arsenic of the shops is however largely employed as a cheap flux for glasses of different kinds, and it acts in this way in a very powerful manner; but if too much is employed, vessels made of it are not absolutely safe for domestic purposes, and are apt to become opaque. The red and yellow sulphurets afford good pigments to the painter.

The most decisive experiments for the detection of arsenic, when suspected to be contained in any substance, are the following. Boiled in water, even the white oxyd (the preparation the most likely to occur) makes a solution of sufficient strength to give very clear indications of its nature. 1st. Sulphuretted hydrogen passed through the solution, or water saturated with the gas, added to it gives a golden yellow precipitate. 2d. An extremely small quantity of carbonat of potash added to the solution, and then mixed with a solution of sulphat of copper, gives a yellowish green precipitate. 3d. The dried substance to be examined, or the solution evaporated to dryness, mixed with a little powdered charcoal, and put into a glass tube closed at the bottom, lightly stopped at the top, and heated slowly to redness, will yield a metallic sublimate, which will give the strong smell peculiar to arsenic, and will condense on the sides of the tube, lining it with a brilliant metallic coating. 4th. The same strong smell, and a dense white fume will be given, merely by sprinkling the powder on hot charcoal. 5th. A little of the reduced regulus, or of the suspected powder, *mixed with a little charcoal*, laid between two pieces of copper (halfpence for example) scoured quite bright, bound round with wire, and heated red-hot for a few minutes, will leave on each piece of copper a bright white stain, which cannot be rubbed off, except by making a new surface. All these marks combined, cannot fail to indicate the presence of arsenic. See TESTS.

ARTICHOKE. See HORTICULTURE.

ASBEST, is of a texture more or less filamentous, and by trituration is reducible to a soft somewhat fibrous powder. It is commonly divided into four varieties, but we shall only notice one, the *Amianth*, the others being of very little importance.

The fibrous texture of amianthus, its incombustibility, and the little alteration that it undergoes even in a strong heat, were early noticed, especially among the Eastern nations; and methods were found out of drawing the fibres into thread, and afterwards weaving it into cloth. This, when dirtied with grease, or other inflammable matter, was cleaned by throwing into a bright fire; the stains were burnt out, and the cloth was then removed, but little altered in its properties, and of a dazzling white; hence it obtained from the Greeks the name αμιαντος or *undefiled.* In the rich and luxurious times of the Roman empire, this incombustible cloth was purchased at an enormous price, for the purpose of wrapping up the bodies of the dead previously to their being laid on the funeral pile. The practice of burning the dead falling into disuse, occasioned the manufacture of amianthine cloth to be neglected, and at length entirely forgotten in Europe; but though it has ceased to be an article of necessity or luxury, yet the method of its preparation has occasionally attracted the notice of travellers and occupied the time of the curious. Ciampini, of Rome, in 1691, published the following as the

best way of preparing the incombustible cloth. Having previously steeped the amianthus in warm water, divide its fibres by gently rubbing them with the fingers, so as to loosen and separate all the extraneous matter; then pour on repeatedly very hot water, as long as it continues to be in the least discoloured. Nothing will be now left but the long fibres, which are to be carefully dried in the sun. The bundles of thread are to be carded with very fine cards, and the long filaments thus obtained are to be steeped in oil, to render them more flexible. A small quantity of cotton or wool is to be mixed, and by means of a thin spindle the whole is to be drawn out into thread, taking care that in every part the amianthus may be the principal material. The cloth being then woven in the usual manner, is to be placed in a clear charcoal fire to burn off the cotton and oil, when the whole remaining tissue will be pure white amianthus. The shorter fibres that are incapable of being woven, have been sometimes made into paper, the process for which is the same as that employed for common paper, except that a greater proportion of paste or size is required: after having been made red hot, however, this paper becomes bibulous and brittle. Amianthus threads are also sometimes used as perpetual wicks for lamps; they require, however, to be cleaned occasionally from the soot that collects about them, and the fibres in the hottest part of the flame are apt to run together, so as to prevent the due supply of oil. In Corsica, amianthus is advantageously employed in the manufacture of pottery: being reduced to fine filaments, it is kneaded up with the clay, and the vessels which are made of this mixture are lighter, less brittle, and more capable of bearing sudden alterations of heat and cold than common pottery.

ASHES, generally speaking, are the remains of bodies reduced by fire. These are vegetable, animal, and mineral ashes; but the first only are strictly entitled to that appellation. We understand, that the French have recently contrived a process of converting the ashes, or residuum of animal substances, decomposed by burning them, into glass, similar to that which is produced in the manufacture of this article, when siliceous earth and wood-ashes are the principal ingredients. This curious conversion of human bodies into a transparent and most beautiful metal, is an ingenious imitation of the practice frequently adopted among the ancients, with a view to preserve the sacred remains of their revered ancestors, or of persons of great worth and merit. But, whether such expedients, if they ever should become general, be compatible with the refined feelings of relations and friends in other countries, we submit to the determination of our sentimental readers. If we may be allowed to express our opinion on so delicate a subject, the scheme may be a very *economical* one, for saving the expences of an ostentatious funeral; and, as such we have mentioned it in this work: but we doubt whether there may be found many individuals in this country, except those few among the *emigrés*, who incline, or deserve, to receive the honours of combustion.

Mineral bodies, when reduced by fire, are properly called *Calxes*, of which we shall treat under that distinct head.

There is a great variety of *wood-ashes* prepared from different vegetables. We have already described the properties of *Alkalies*, and shall at present observe, that vegetable ashes contain a great quantity of *fixed salt*, blended with earthy particles; and that from these ashes are extracted the fixed alkaline salts, called *Pot-ash*, *Pearl-ash*, *Barilla*, &c. of the preparation, and properties of which, we propose to treat under their respective heads. Confining, therefore, our account to ashes, in their unchanged and crude state, we shall give the following description of the different useful purposes to which they are subservient, in domestic and rural economy.

Dr. Francis Home, of Edinburgh, who may be considered as the earliest benefactor of the Scottish cotton manufactories, justly observed, in an ingenious treatise, entitled *Experiments in Bleaching*, that the proper application of alkaline leys, is one of the most important and critical articles in the whole process of that art. See BLEACHING.

In rural economy, ashes have, since the days of Virgil, been considered as one of the best, and easiest means of fertilizing land; yet many objections have been started, by modern writers, against their use; probably because they were indiscriminately employed for *all* kinds of soil, whether moist or dry, cold or warm, loose or clayey. Hence we need not be surprised that agriculturists have differed in opinion on this subject. Without detaining the reader with speculations concerning the manner in which ashes act on the soil, in promoting its fertility, we shall briefly observe, on the authority of the best writers, supported by experience:

1. That vegetable ashes, in general, are most effectual for manuring moist, cold, boggy, marshy, or uncultivated soils.

2. That ashes are no less fit for manure, after the salt is extracted from them, than before; and, if there be any difference, it is in favour of the washed ashes.

An anonymous correspondent in the Gentl. Mag. for June, 1766, appears to have derived the first hint respecting the advantages of *peat-ashes* in dressing land, and a method of preparing coal-ashes for the same purpose, from the *Dictionnaire Economique*, or the Family Dictionary, translated from the French by the late Prof. Bradley, of Cambridge, and published in 1725. In this curious work, which equally abounds with excellent and frivolous remarks, we find the following passage: "Turf and peat ashes are very rich; producing, when spread upon land, an effect similar to that of burning the soil." Perhaps it is in consequence of this suggestion, that we find in the Magazine before alluded to, an account of too interesting a nature to withhold it from our readers.

Peat-ashes, properly burnt, afford an excellent manure for both corn and grass-land; but the most valuable are those obtained from the lowest stratum of the peat, where the fibres and roots of the earth are most decayed. This will yield a large quantity of very strong ashes, of a colour, when recently burnt, resembling vermillion, and of a very saline and pungent taste. Great care and caution should be used in burning these ashes, and likewise in preserving them for future use. The method of burning them is similar to that of making charcoal. After the peat is collected into a large heap, and covered, so as not to flame out, it must be suffered to consume slowly, till the whole substance is reduced to ashes. Thus burnt, they are found excellent in sweetening sour meadow-land, destroying rushes, and other bad kinds of weeds, and producing in their place great quantities of excellent grass. In some parts of Berkshire and Lancashire, they are considered one of the best dressings for spring crops.

A very great improvement may likewise be made, and at a moderate expense, with *coal-ashes*, which, when properly preserved, are a most useful article for manure. By putting one bushel of lime, in its hottest state, into every cart-load of these ashes, covering it up in the middle of the heap for about twelve hours, till the lime be entirely fallen; then incorporating them well together, and by turning the whole over, two or three times, the cinders or half burnt parts of the coals, which instead of being useful, are noxious to the ground, will be reduced to as fine a powder as the lime itself. For this purpose, however, the coal-ashes should be carefully kept dry: and, thus prepared, they are the quickest breakers and improvers of moorish and benty land.

Professor Bradley, in his dictionary before mentioned, farther observes, that *soap-ashes* are highly commended by Mr. Pratt, as being, after the soap-boiler has extracted them, eminently fructifying, and that the ashes of any kind of vegetables are profitable for enriching barren grounds, as they promote the decomposition of moss and rushes, in a very great degree. The best season for laying them, either for corn, pasture, or meadow, is said to be in the beginning of winter, in order that they may the more easily be dissolved by showers of rain.

Having given this view of the subject, from the collective experience of British writers, we shall also communicate a few practical facts, derived from authentic German authors.

According to their experience, *pot-ash* is most usefully employed for correcting a sandy and loamy soil; the ashes obtained from the hardest woods, being the most beneficial, and among these, the beech and oak are generally preferred. A small addition of quicklime to the pot-ash, tends considerably to increase its fertilizing property.

The refuse of *soap-boiler's ashes*, is likewise used in Germany, with the best effect, when sprinkled, soon after sowing, either in spring or in autumn, as closely as possible, over fields of wheat, rye, spelt, lentils, pease, beans, barley, lint-seed, hemp, millet, and similar grain. An acre of wheat, or barley, requires however a much greater proportion of these ashes, than one sown with rye, or corn of an inferior quality. They are farther employed with great advantage, by scattering them on meadows in the early part of spring. Leached ashes are much used in some parts of the United States as a manure. Great quantities are annually taken from the city of Philadelphia to Long Island, for the purpose. They cost here 40 cents per one horse cart-load, and commonly bring one dollar 50 cents, when delivered. From a paper in the first volume of the *New York Agric. Soc. Trans.* by M. E. D'Hommedieu, it appears, that ashes are found to succeed best on dry loamy lands, or loam mixed with sand. It is considered as the cheapest manure that can be procured. Ten loads of this manure, on poor land, will produce ordinarily twenty-five bushels of wheat, which exceeds, by five dollars, the expence of the manure, and the five

raising the crop. The land is then left in a state for yielding a crop of hay of between two and one-half tons per acre, which it will continue to do for a great number of years. No manure continues so long in the ground as ashes. See Agriculture.

ASSAY or *Essay*. The term ASSAY, in chemistry, in a general sense, implies the analysis or examination of a sample of any substance, whose chemical composition is to be ascertained; but this term is also technically restricted to the analysis of gold and silver mixtures, with the express and sole purpose of determining the proportion of noble metal to that with which it is alloyed, in any individual mass. It is only in this sense that we here understand it, and on account of the vast quantity of coin, plate, and plate ornaments which are constantly fabricated, the business of the assayer becomes of extreme importance; for few operations in chemistry require so nice and minute attention, and such practical experience as one, which, from the sample of a few grains, is to decide the standard of very large masses of the most valuable metals.

Gold and silver assaying is, however, in principle extremely simple, the whole being included in two operations, namely, the separation of the alloy from the noble metals, and the parting of these latter (gold and silver) from each other. These processes must be considered separately.

Of all the metals hitherto known, three alone, gold, silver, and platina, are incapable of oxidation by simple exposure to air, either when solid or in a state of fusion, and hence they acquired the antient name of *perfect* or *noble* metals. All the other metallic bodies tarnish and oxidate, when in fusion in open vessels, with more or less facility, and by constantly removing the oxidated surface from the melted metal, the whole may be successively converted to an oxyd. Here, therefore, is a method of separating the imperfect from the perfect metals, when the two species are mixed; namely, to melt the mixture and keep it in fusion with access of air, when the *alloy*, or imperfect metal will separate at the surface in oxidated scales, and the noble metal remain unaltered. This separation, however, is not in all cases equally exact, for when gold or silver is alloyed with a metal not very easily oxidable, though imperfect, such as copper, and when the proportion of the alloy to the noble metal is but small, the affinity of the latter to the former encreases so much as to protect it from any further action of the air, however long the fusion is kept up. Thus a mass of eleven parts of silver to one of copper, oxidates but lightly by a long continued melting heat, nor could the whole of the copper be extracted from the mixture by heat alone. Another difficulty in the way of this separation is the very difficult fusibility of the oxyd of copper (for all metallic oxyds by heat melt into a species of coloured glass), so that in a heat much above that at which the mixture remains in fusion, the crust of oxyd clings unmelted to the surface of the fluid metal, and unless sedulously removed, it there remains, and prevents the further action of the air on the alloy, by which alone all the imperfect metalcan be thrown off from the mass.

But chemists have found that the separation of many of the imperfect metals is much promoted by adding to the mixture a quantity of a metal, itself highly oxidable, and its oxyd easily fusible, which unites with the original alloy of the mixture, encreases its oxidability, carries it off dissolved in the vitrified oxyd, and thus compleatly extracts from the mass all the impefrect metal or alloy, leaving the noble metal or metals pure.

A few of the more fusible white metals have been tried for this purpose, particularly lead and bismuth; but lead is found to answer the end better than any other, and is the only substance actually used. Hence litharge, the oxyd of lead, was termed by the antient chemists, not unaptly, *the bath*, of the noble metals, *scouring* or *cleansing*, them, as it were, from all their alloys of base metal, and leaving them quite bright and pure.

This process of oxidizing the alloy by lead is employed in the large way in the *refining* of gold and silver; in small samples, with the peculiar precautions to be presently mentioned, it forms the process of *cupellation*, which, therefore is the first and most important part of the assayers business.

The second process is the separation of the gold from the silver, where both metals are present, for being equally perfect, or unoxidable by mere fusion, they are left uniformly mixed by melting, after the alloy has been separated by cupellation. The method of separating gold from silver is by the nitric acid, which, if properly managed, may be made to dissolve all the silver and leave all the gold. This process is called *Parting*, and is the second great operation of the assayer. Platina may in general be put out of the question, and it seldom is contained in any gold or silver alloy actually used, but when present it occasions some peculiar appearances, which will be afterwards noticed.

dollars pays for the expence of labour in

Cupellation. This process is performed in a furnace contrived for the purpose, and capable of giving a heat at least sufficient for the easy fusion of gold. In the middle of this furnace is placed an earthen pot called a *muffle*, of an oven form, vaulted at top, with a level floor at bottom entirely open at one end, and closed every where else, except a few narrow openings through the sides. The open end comes in contact with a door at the side of the furnace, and is generally luted thereto, so as entirely to separate it from the burning fuel. The body of the muffle is surrounded with the coals, and before cupellation is gradually heated to a glowing redness. Its use is to protect the small crucibles or cupels, ranged on its floor, from any accidental impurity which the fuel might furnish, and at the same time to afford the melted metal a free access of heated air to promote the oxidation. The cupels are solid pieces of earth, cubical or circular, with a shallow depression at the top to contain the metal, and small in proportion to the size of the muffle, so that the floor of this latter will hold several of them side by side. They are made solid, but at the same time so porous as freely to absorb the lead, in proportion as it oxidates and vitrifies, whilst the globule of metal that remains in the reguline state rests on the surface. Cupels may be made of any infusible earth of little cohesion, such as the ashes left after the lixiviation of the residue of burnt wood, which are much employed in refining, or cupellation in the great way, but for assaying they are made entirely of bone-ash (phosphat of lime) ground to a fine powder, moistened with water, so as to take the impression of a mould, and afterwards thoroughly dried. The cores of ox-horns are preferred at the Tower Assay-Office.

The fire being kindled, the muffle and empty cupels are first heated gradually, till the whole are of a glowing red, a little powdered chalk or sand being first sprinkled on the floor of the muffle, to prevent the adhesion of the cupels by the litharge soaking through them. They are then ready to receive the metal to be cupelled. It should be observed that the cupels of bone-ash cannot absorb more than their own weight of litharge at the utmost, and hence the quantity of fine metal to be assayed should not require more lead than the weight of the cupel. The proportion of lead to the fine metal is determined by the estimated purity of the latter, as will presently be mentioned.

Experience has shewn the extreme difficulty of conducting cupellation at times with perfect accuracy, even to persons habitually employed in this delicate operation, and many valuable series of experiments on this subject have been undertaken by able assayers, among which we may particularly mention those of M. Tillet, and his associates, nominated by the French government, and published in the memoirs of the academy in the years 1763—9—75—6—8—80—8.

Assay of Silver.—For the assay of silver, in this country, a clean piece of the metal is first taken, not more than 36 grains, and less if the alloy appears to be considerable, is laminated, and weighed with extreme accuracy in a very sensible balance. It is then wrapped up in the requisite quantity of lead, revived from litharge, and for convenience rolled out into a sheet; or else the silver and lead may be together closed in paper. The purity of the lead is of importance, as all lead only once reduced from its ore contains some silver, the quantity of which might make some notable error in the delicate operations of the assayer. But when revived from litharge lead retains no more than about half a grain of silver to the pound, which may be entirely neglected.

When the muffle and cupel are fully red hot, the silver and lead are then put in the cupel with a pair of pincers, when they immediately melt; and when red the following appearances take place. The melted metal begins to send off dense fumes, and a minute stream of red fused matter is seen perpetually flowing from the top of the globule down its sides to the surface of the cupel, through which it sinks in and is lost to view. This fume and the stream of melted matter consist of the lead oxidated by the heat and air, in one case volatilized, in the other vitrified, and in sinking through the cupel it carries down with it the copper or other alloy of the silver. In proportion to the violence of the heat is the density of the fume, the violence with which it is given off, the convexity of the surface of the globule of melted metal, and the rapidity with which the vitrified oxyd *circulates* (as it is termed) or falls down the sides of the metal. As the cupellation advances, the melted button becomes rounder, its surface becomes streaky with large bright points of the fused oxyd, which move with increased rapidity, till at last the globule being now freed from all the lead and other alloy, suddenly *lightens*; the last portions of litharge on the surface disappear with great rapidity, shewing the melted metal bright with iridescent colours, which directly after becomes opake, and suddenly appears brilliant, clean, and white, as if a

curtain had been withdrawn from it. The operation being now finished, and the silver left pure, the cupel is allowed to cool gradually, till the globule of silver is fixed, after which it is taken out of the cupel while still hot, and when cold weighed with as much accuracy as at first. The difference between the globule and the silver at first put in, shews the quantity of alloy, the globule being now perfectly pure silver, if the operation has been well performed. The reason of cooling the globule or button gradually is, that pure silver, when congealing, assumes a crystalline texture, and if the outer surface is too suddenly fixed, it forcibly contracts on the still fluid part in the center, causing it to spurt out in arborescent shoots, by which some minute portions are often thrown out of the cupel and the assay spoilt.

In the delicate assays for the Mint, in the Tower of London, two assays are always made of the same mass of metal, and no sensible difference between the weight of the two buttons is allowed to pass, ascertained in scales which turn with $\frac{1}{1200}$ of a grain troy. If they differ the assay is repeated.

The process is considered as well performed when the button of silver adheres but slightly to the cupel; when its shape is very considerably globular above and below, not flattened at the margin; when it is quite clean and brilliant, shewing the beautiful white of pure silver, and not in any degree fouled or spotted with any remaining litharge; and especially when the surface of the metal is disposed in scales or laminæ, the effect of a strong but hasty crystallization, which gives it a play of light and a striated lustre very different from that of a perfectly even surface of a white metal, however pure. Examined by a microscope, this striated surface is still more striking; the scales appear to affect the form of an irregular pentagon, slightly depressed at the centre, and the surface is decidedly uneven. On the other hand, when any alloy is left in the silver, the surface, though it may be quite brilliant, appears under the microscope as smooth as if varnished, and scarcely at all scaly in texture.

In common assays of plate, either gold or silver, copper is the alloy usually met with; if the fine metal be nearly pure, the cupel round the bottom is only stained yellow by the litharge; if copper is contained, it leaves a brown grey stain; the other metals, except bismuth, scarcely penetrate the substance of the cupel, but remain on the edges of its cavity in the form of coloured scoriæ, of which iron is black, tin grey, and zinc a dull yellow.

The management of the fire is a point of great consequence in cupellation, and several important cautions are given by the most experienced assayers. When silver is kept in fusion in a very high heat, a portion of it is volatilized, so that if a cupel is inverted over another containing the silver thus intensely heated, the upper one will after a while be found studded over with minute globules of silver, very visible through a common lens. M. Tillet found that a button of pure silver, kept in a very high heat for two hours in a cupel, lost no less than $\frac{1}{20}$ of its weight, and hence the error which this may produce in assaying is considerable, and makes a return of a metal of less purity than is really the case. The heat is known to be too great when the cupel can scarcely be distinguished from the muffle, when the fume given off from the metal can hardly be seen for the dazzling heat, and mounts up to the dome of the muffle with great rapidity On the other hand, when the fire is too slack, the litharge is not absorbed by the cupel, but lies on the surface as a red scoria, the circulation is sluggish, the button flat, and the fume very small. Towards the end of the operation, the heat should be gradually increased, for in proportion as the lead is abstracted from the alloy, it becomes less easy of fusion, and at last a heat fully equal to the melting of pure silver is required.

As cupellation requires a free access of air, as well as high heat to oxidate the metal, the stopper of the furnace immediately opposite the mouth of the muffle is altogether removed as soon as the metal is put into the hot cupel, to allow a current of external air to draw in and circulate through the muffle: but to prevent this from cooling the muffle too much, a small iron platform is made to project from this orifice, on which several long cylinders of charcoal are heaped up, which kindling on the edge of the red-hot muffle, burn with sufficient force to heat the external air in its passage to the cupels. The rapidity of oxidation is in a great measure regulated by the degree in which the mouth of the muffle is blocked up by these pieces of charcoal, being the greatest when the charcoal is no more than sufficient to keep up a due heat within, and allow the air to pass over it freely. The fuel of the furnace, which heats all the rest of the muffle, is totally unconnected with the charcoal at the orifice. The surface should be made so that the heat of the fuel within may be readily en-

creased or diminished, but at the same time should be able to be kept up with steadiness and regularity.

The speediest method of encreasing or diminishing the heat of the assay, when the muffle is not too much crouded with cupels, is to push the cupel towards the further end of the muffle, to where the heat is the most intense, being in the middle of the fire; or, on the other hand, to lessen the heat, to draw the cupel nearer the opening of the muffle, and remove a piece or two of the charcoal from the mouth.

The time taken to perform one silver assay from putting the metal into the hot cupel to the *lightening* or purity of the button, is in general from fifteen to twenty-five minutes, but the precise time seems to be of little consequence, the button being equally pure after a rapid as a slow cupellation. The danger of error from too great heat in volatilizing part of the silver, has been already mentioned, but at all times as much external air may be admitted into the muffle as possible, consistent with keeping up a due heat.

The proportioning the lead to the estimated quantity of alloy in the silver to be essayed, is a subject of more importance than might at first be expected. An assay is known to have had too little lead when the button is very flat, rough at the edges, dull in colour, with blackish spots, strongly adherent to the cupel, and foul with scoriæ on and about the button. But at first view it would seem to be immaterial how *much* lead is added, so that it be sufficient to separate all the alloy, as the whole lead, whether more or less, will equally be oxidated by the cupellation sooner or later. This is shewn by the cupellation of lead *per se*, when done to ascertain its natural quantity of silver, the whole readily scorifying in the process, and leaving only a minute globule of the noble metal. But the loss in assaying by using an excess of lead, is more than the mere waste of time and fuel, and for the following reason; M. Tillet found by experiment that when perfectly pure silver was cupelled with lead, whose natural retent of silver was known, the button of silver remaining after the process was never precisely of the same weight as before, but always a certain proportion less, even when the heat was not sufficient to drive off any of the silver. This indicated that a part must have been carried down by the lead into the cupel, and it was proved by afterwards reducing the oxyd of lead out of the cupel, and cupelling this lead by itself, when the quantity of silver left was found to be ten times as great as the natural proportion of this metal, and almost exactly to correspond to the loss of silver in the first instance. Hence it follows that the assayer's report of the title or purity of any sample of silver (unless corrected) always makes the metal a little less pure than in reality, the loss of weight in the button being entirely put to the account of alloy. When no more lead is used than necessary for the perfect separation of the alloy, M. Tillet reckons that it carries down into the cupel as much silver as, when the whole is again reduced, would make the noble metal $\frac{1}{128}$ of the mass, when the natural admixture of silver is only about $\frac{1}{1152}$. But if an excess of lead is employed for cupellation, this loss of silver is somewhat greater, though it does not encrease in the ratio of the excess of the lead, for ten parts of lead to a given alloy will not carry down twice as much silver as five parts, though the difference of loss will be very sensible.

It might be supposed that as the litharge of the first assay has been able to carry down a certain portion of silver into the cupel in the first instance; the same when again reduced to reguline lead could not be made to restore its excess of silver by mere cupellation *per se*. This however is not the case, for the second cupellation is found to leave a button of silver fully equal to the loss of this metal in the first assay, the lead only carrying down its natural retent of silver, that is about $\frac{1}{1152}$ of its weight, as above mentioned. If the litharge of the second cupellation is again reduced and the lead cupelled a third time, an extremely small globule of silver is left, scarcely visible to the naked eye. Again reduced and cupelled, a minute grain of silver, only visible by a lens, is left on the cupel, after which the quantity becomes so small as to elude the senses. This is a convincing proof against the conversion of lead into silver by cupellation, as formerly supposed by some chemists of considerable name, the silver being obviously only extracted from the lead in these processes, and not generated from it. In all these reductions the silver appears equally distributed through the lead, for M. Tillet found that separate globules of lead by accident spurted out upon an empty cupel in the muffle, each left a minute atom of silver lying upon the spot where the globules had scorified.

Bismuth will serve the same purpose as lead in cupellation, but besides that is a dearer metal and not always easily procurable, it is found to carry down with it in-

to the cupel somewhat more of the silver than the same quantity of lead does.

As the lead must be proportioned before cupellation to the estimated quantity of alloy in the silver, a method must be found of forming this estimate with sufficient exactness. The ancient assayers made great use of TOUCH-NEEDLES, or small slips or bars of metal, made with pure silver, alloyed with known proportions of copper, in a regularly increasing series from the least to the greatest proportion ever required. The silver to be assayed was then examined in comparison with the touch-needles, in colour, tenacity, and other external characters, and its alloy was estimated by that of the needle, to which it shewed the closest resemblance. These needles are now however almost totally disused in silver assaying, an experienced assayer being able to judge of the alloy with quite sufficient exactness, by the ease or difficulty with which it is cut, the colour and grain of a fresh cut surface, the malleability, the change of surface when made red hot, and the general appearance.

Assay of Gold.—The assay of gold is somewhat more complicated than that of silver. Silver, if not mixed with gold or platina, requires only the single operation of the cupel to separate its alloy and ascertain its purity; if mixed with gold, though the latter be in a small proportion, it is called a gold assay, on account of the superior value of this metal. Copper, or any other base metal, when mixed with gold may indeed be separated from it by cupellation with lead as from silver, but it is found by experience that the affinity of copper to gold is so strong as scarcely to be overcome by this method, unless the mixture be first combined with a certain quantity of silver before cupellation. This therefore necessarily requires a subsequent operation, namely that of separating the gold from the silver when mixed in the button left after cupellation.

Gold is also frequently alloyed intentionally with silver in some foreign coins, and in some kinds of manufacture. The process of *parting*, or separating gold from silver is performed by a dilute nitric acid (or aqua fortis as it is constantly termed in manufacture) the acid dissolving the silver and leaving the gold untouched. But here another singular circumstance occurs: it is found that when the gold is in considerable proportion in the mixture, it so much protects the silver from the acid as to prevent its action more or less completely, and the parting is imperfect. Therefore, when these metals are thus mixed, it becomes necessary to add so much silver as to give this metal a great excess over the gold. About three of silver to one of gold are generally considered to be requisite, and hence the process of parting has also been called *quartation*, the relative proportion of the gold being reduced to no more than *one-fourth* of the mass. Any greater proportion of silver than three-fourths may be parted with equal certainty, but for a particular convenience in managing the process and to save needless trouble, when silver is to be intentionally added, no more is taken than will give the above composition. It may be observed however that many good assayers consider three parts of silver to one of gold as more than necessary, and that about two will suffice.

It would seem at first sight, that in gold assaying, as both silver and copper (the usual alloy of gold) are soluble in aqua fortis, the first process of cupellation might be spared, and the parting alone resorted to. This is indeed sometimes done, the gold assay piece being simply melted with the requisite quantity of silver and immediately parted by means of the acid. But as the entire quantity of materials for the assay is only a few grains, and as the intimate mixture with the silver is a point of great consequence, it is found better on the whole first to cupel them with lead (even when no copper is present and the original alloy of the gold is only silver) that they may be thoroughly combined and be collected into a small neat globule, without risk of losing or dispersing any minute portions.

The cupellation of gold therefore is conducted in the following manner. Its proportion of alloy being first estimated by the touch, as will presently be explained, and the small piece designed for the assay being weighed with extreme accuracy, as much silver is taken as is estimated to be necessary to make the entire quantity of this metal about thrice the weight of the pure gold; the requisite proportion of lead is also taken, and all three are put on the hot cupel, where they melt and combine almost immediately. The proportion of lead to the alloy of base metal is nearly the same as for silver assaying, the quantity will be seen by the subjoined table. The process of cupellation is conducted nearly the same as for silver, only a greater heat is required throughout in gold assaying, and this may be used with freedom, as none of the gold, or rather the mixture of gold and silver, is lost by volatilization, as pure silver is. The *lightning*, or sudden luminous brightness

of the button, when all the lead is worked off, takes place here as in silver assaying, and when cooled the button is taken out and weighed. It now consists only of gold, with about three times its weight of silver; the copper, the original alloy, having been worked off along with the litharge. Strictly speaking however, the button is not absolutely pure, as gold when cupelled with lead always retains a minute portion of this latter metal, which may be got rid of chiefly by being kept a little time in fusion on a clean vessel covered by a small crucible. The lead totally disappears after parting. The cold button is then flattened with the hammer, again heated red hot, and slowly cooled to anneal it and encrease its malleability, then passed between rollers of polished steel, to extend it into a small plate about as thin as a wafer, again heated only to redness, and lastly rolled up into a small loose coil. The use of the annealing is to allow the plate to roll up without cracking, and at the same time to open the texture of the metal somewhat closed by the rolling, to allow the free action of the aqua fortis in the subsequent operation of *parting*.

Before we describe this process we shall mention the way of estimating the alloy of gold before cupellation, which is necessary for giving it the due portion of lead. The fineness of silver, as we before observed, is ascertained partly by touch-needles of silver and copper, but principally by the appearance, hardness, and other external characters which experienced assayers can estimate to very great nicety. Gold is partly judged of by the same method, but it is more complicated than in the former case, as three metals are here concerned in the usual alloys, namely, gold, silver and copper, so that the assayer has to judge of every proportion of admixture of gold and silver, gold and copper, and often gold, silver and copper. An experienced artist, if he knows the nature of the alloy, can nearly tell its proportion by mere inspection and cutting the surface; but if touch-needles are here used, there must be several sets of them, adapted to the nature of the alloy. Four sets of these are commonly directed; one in which pure silver is used for the alloy, another in which the alloy is a mixture of two parts silver and one copper, a third with two parts copper and one silver, and a fourth of copper only. These are severally weighed out most carefully, with every requisite portion of the finest gold, encreasing in twenty-fourth parts, and melted together; but with the three last very little use can be made of mixtures of low denomination, for where the copper is in large quantity, the change which it gives to the colour of gold is not easily distinguished from the hue of different species of copper. In melting these mixtures, besides the usual precautions against accidental loss, borax is used as a flux to facilitate the union of the metals, and some pitch or tallow should be kept burning on the surface, to prevent the loss by oxidation of part of the copper, which would alter the intended proportions. As soon as ever they are melted and stirred together they should be taken out of the fire. But Mr. Hatchett's late experiments on the alloys of gold have shewn that the difficulties of producing a perfectly uniform alloy of these metals by fusion, are so great as very much to lessen the confidence to be placed in touch-needles for the smaller divisions.

Another ingenious and simple method* is resorted to for estimating the proportion of gold to all other metals (platina excepted) in any alloy. It is the operation of *touching*. For this purpose a tolerably hard dark-coloured, smooth grained, even stone is selected, such as the black basalt, (or some kinds of fine black pottery will answer very well) the piece of metal to be tried is rubbed on it backwards and forwards, so as to make a broad bright metallic streak on the touch-stone, which shews the colour of the alloy, and may be usefully compared with another streak made beside it by the touch-needle, to which it bears the nearest resemblance. The colour is heightened by being wetted before examination. In this simple method, and by the assistance of good touch-needles, a practised eye will tell to great nicety the proportion of gold when the nature of alloy is known. The Chinese are said to distinguish by this means as nearly as to the 200th part of gold in the alloy of gold and silver, and in the extensive commerce of the precious metals throughout the East Indies this is said to be the only method of trial commonly adopted.

The nitric acid is also of singular service in the trial of *touching*, and is used to ascertain absolutely the quantity of gold, whether the alloy be copper or silver, or any other metal except platina. This is in fact performing in the rough way a kind of parting. When the streak on the stone has been examined by the eye, a drop of aqua-fortis is let to fall and gently spread over it. In eight or ten seconds it is washed off, and the effect observed. If the streak preserves its golden brilliance unaltered, the metal is judged to be of a

certain degree of fineness; if it looks red, dull and coppery, it is less fine; if the streak is almost entirely effaced, the metal contains very little gold, and thus by that experience, which no description can teach and nothing but actual practice can give, a good assayer will form a very tolerable judgment of the value of his sample.

But it is found in touching that pure nitrous acid, of whatever strength, will not act in any very decided manner upon the alloy of copper and gold, when this latter metal is as much as two-thirds of the mass, and hence this process is chiefly of use in the lower mixtures. But if a small portion of muriatic acid is added to the nitrous, the activity of the menstruum is so much encreased that any mixture below three-fourths will be acted on, and consequently the power of this operation is much extended. Gold therefore protects the alloy from the acid to a very great degree, and this is similar to what is found in parting, as the gold must not be more than a fourth, or at most a third of the mass, to allow of the separation of its alloy. The best acid for touching is recommended by Vauquelin to be 98 parts of nitric acid of 13.4 specific gravity, 2 parts of muriatic acid of 11.73 specific gravity, and 25 parts of water. This nitro-muriatic acid, it may be observed, does not act sensibly on the gold of the streak on the touchstone, the application being so short, without heat, and especially the muriatic ingredient being in such small proportion. Touching is particularly of use in judging of the value of very small samples of gold, wrought trinkets, and such pieces as cannot spare as much as six or eight grains for an assay. As it only gives the fineness of the surface which is abraded, caution is necessary where plated metal is suspected, or where the surface is artificially made finer than the inner part.

Of Parting.—The button of gold and silver left after cupellation, having been laminated and rolled into a spiral in the way above mentioned, is called a *cornet;* it is then put into a glass mattrass, of a pear-form, called a *parting-glass*, and about twice or thrice its weight of pure nitric acid moderately diluted (M. Vauquelin recommends 1.25 specific gravity) is poured on it, the glass is set on a sand bath or over charcoal to boil, the mouth being slightly covered to keep out the dust. When warm, the acid soon begins to act on the silver, and dissolves it with the usual evolution of nitrous fumes. As long as the acid continues to act, the cornet is studded all over with minute bubbles; when these discontinue, or unite into a few large ones, it is a sign that the acid has ceased to act. About fifteeen or twenty minutes from the time the acid boils, is required for this process. The cornet is now corroded throughout, having lost by the solution all the silver, which was from two-thirds to three-fourths of its substance: the gold retains the same coiled form, but is very slender and brittle. It is of importance that it should not be broken, as it tends much to the accuracy of the business to have all the gold in one piece and not in fragments, and this is the chief reason why no more silver than absolutely necessary is added before cupellation; for it is obvious that the less the proportion of gold in the cornet the more likely it will be to fall to pieces on the slightest agitation. The hot acid solution of silver is then poured off with great care, and fresh acid, rather stronger, is added, to clear away all remains of the silver, and boiled as before; but only for five or six minutes. It is then decanted and added to the former solution, and the parting glass is filled with hot distilled water, to wash off all the remains of the solution. This is decanted off, and at the same time the cornet, now brown, spongy and unmetallic in appearance, is got out by the following little manual dexterity. A small crucible is inverted over the top of the parting glass whilst full of water, the latter is then rapidly inverted upon the crucible, and the cornet falls softly through the water down the neck of the glass into the crucible, where it is gently deposited and the water carefully decanted off. The crucible is then dried and heated under a muffle to redness, by which the cornet shrinks extremely in every direction, becomes firm, regains its metallic lustre, and when fully red hot and cooled, it appears a small cornet of pure gold, with all the beautiful lustre, softness and flexibility of this noble metal. This is then most accurately weighed and the process is finished,

The final weight of the gold cornet indicates the absolute quantity of this metal in the assayed sample: the difference between the weight of the button after cupellation (deducting the silver added) and the first sample is the weight of the copper or other *base* metal in the gold; and the difference between the gold cornet together with the silver added, and the button after cupellation is the quantity of silver alloyed with the original gold.

The solution of silver left after parting is usually recovered by immersing in it, when collected in quantity, some bright

copper plates, which dissolve and precipitate the silver in its metallic form It may also be recovered by a solution of common salt, which converts the silver into luna cornea, of which when washed and fully dried at a heat below redness, 100 parts indicate 75 of silver. The accuracy of the assay may be partly verified by this method.

Assay Weights.—A peculiar set of weights have been used by the different nations in the assaying of gold and silver, which require to be explained. The real quantity taken for an assay is always very small, in this country generally from 18 to 36 troy grains for silver, and from 6 to 12 grains for gold. This is the integer, and whatever be its real weight it is denominated the assay pound. This imaginary pound is then subdivided into aliquot parts, but differing according to the metal. The *silver* assay pound is subdivided as the real troy pound into 12 ounces, each ounce into twenty pennyweights, and, for assaying, these again into halves. So that there are 480 different reports for silver (this being the number of half pennyweights in the pound) and therefore each nominal half dwt. weighs one-twentieth of a troy grain, when the entire assay pound is 24 grains.

The report is made according to the proportion of fine metal, thus standard silver of England is reported by the assayers to be 11 oz. 2 dwt. *fine*, meaning thereby that the remainder of the pound is composed of 18 dwt. of alloy or copper, or in other terms that there are 37 parts of silver to 3 of copper. The gold assay pound is subdivided into 24 carats, and each carat into 4 assay grains, and each grain into quarters. So that there are only 384 separate reports for gold. The standard for gold coin is 22 carats *fine*, and of course 2 carats alloy. When the gold assay pound or integer is only 6 troy grains, the quarter assay grain only weighs 1-64th of a troy grain. This will give an idea how accurate must be the scales used for such delicate operations.

Assayers also make their report upon gold and silver as being *better* or *worse* than the established standard. Thus gold of 20 carats would be reported as *worse* 2 *carats*, being that proportion less than the standard of 22 carats.

When a mixture of gold and silver is the subject of enquiry, if the quantity of gold exceed that of silver, it is called *gold parting:* if the contrary, *silver parting*, and the return is made accordingly, but with this distinction: in silver parting the report is first made on all the fine metal collectively, as if for silver alone, so if 10 oz of fine metal be found, the assayer reports *worse* 1 oz. 2 dwt. that is, 1 oz. 2 dwt. lower than the standard of silver.

When the assay pound is subdivided, as for silver, in the same manner as the troy pound, it is obvious that all the lower denominations bear the same relation to each other; which is some little advantage in transferring the assay reports to real mixtures for use. On the contrary, the carat subdivision for gold, is confined to assaying, but its fractions being aliquot parts of the troy pound, the calculation for real use is very easy: as the troy pound contains 5760 grs. the carat corresponds with 240 grs. or 10 dwt. the assay grain or 4th of a carat with 60 troy grains, and the assay quarter grain with 15 troy grains. To which report, when the assayer has separated the gold (4 oz. for example) he adds 4 *oz. gold in a lb. troy.* Whereas in gold parting he takes two equal assay pieces, treats one as a silver assay, and the other as a gold assay, to find the absolute quantity of each metal, after which the report is first made on the gold singly, to which is added the report of the silver separately. Thus if he finds 4 oz. of gold and 3 oz of silver, he reports *worse* 14 *carats*, (2 carats being equivalent to an assay ounce, and consequently the 4 oz. of gold equal to 8 carats, which subtracted from 22 carats, the gold standard, leaves 14) to which report he adds *fine silver* 3 *oz.* But when the mixed metal contains more than half alloy, it is called *metal for gold and silver*, and the absolute quantity of each reported separately

The assay pound, or integer, is divided in a different manner in several parts of Europe. In France before the late alteration of weights the gold assay was divided into 24 carats, and the carat subdivided into 32 parts, making an ultimate division of 768 parts. The silver assay pound was divided into 12 deniers, and the denier into 24 grains, making 288 grains in the pound.

The Cologne assay weights, used in most parts of Germany, are the following. For gold the integer, here called a *mark*, is divided into 24 carats, and each carat into 12 grains, making 288 ultimate divisions. For silver, the mark is divided into 16 loths, and the loth into 18 grains, also making 288 subdivisions.

The Chinese use the decimal division for gold as well as silver. The integer

contains 100 *touches*, and the simple use of the touchstone will enable the expertest dealers to ascertain with much accuracy, to the $\frac{1}{2}$ touch or 200th of the integer.

The French have of late years adopted the decimal method, consistently with their general system of decimal numeration. The integer for assaying (both gold and silver) is the *gramme*, equivalent to about $15\frac{1}{2}$ troy grains, and the assay subdivisions are the same as those established for the gramme, being tenths, hundredths, and thousandths.

It remains to give the proportions of lead to the estimated alloy of fine metal necessary to be added for cupellation. The most authentic documents for this purpose are probably the very careful experiments of Messrs. Tillet, Hellot, and Macquer, which were the basis of a regulation subsequently adopted by an edict of the late French government.

Copper, the usual alloy of the fine metals, when taken singly is found to require from ten to fourteen times its weight of lead for complete scorification on the cupel. Now all admixtures of fine metal tend to protect the copper from the action of the litharge, and the more obstinately, the greater the proportion of fine metal. So that copper with three times its weight of silver (or 9 oz. fine) requires 40 times as much lead as copper, with 11 parts of silver requires 72 of lead, and the like in an increasing ratio. The following is the table of the proportions of lead required to different alloys of copper, of which a few points are founded on the above-mentioned experiments, and the rest filled up according to the estimated ratio of increase (being multiples of the assay integer 24, in arithmetical progression). In the three first columns is shown the absolute increase of the quantity of lead in alloys of decreasing fineness: in the three last columns will be seen the gradual diminution of the protecting power of fine metal against scorification, in proportion to the increase of alloy shown by the decreasing quantity of lead required for the same weight of copper, under different mixtures.

TABLE.

Silver.		Copper.		Lead.	Ratio of increase.		Copper.		Silver.		Lead.
23	with	1	requires	96	(= 4×24)	and hence	1	with	23	requires	96
22	—	2	—	144	(= 6×24)	—	1	—	11	—	72
20	—	4	—	192	(= 8×24)	—	1	—	5	—	48
18	—	6	—	240	(=10×24)	—	1	—	3	—	40
16	—	8	—	288	(=12×24)	—	1	—	2	—	36
14	—	10	—	336	(=14×24)	—	1	—	$1\frac{2}{5}$	—	33
12	—	12	—	384	(=16×24)	—	1	—	1	—	32
10	—	14	—	432	(=18×24)	—	1	—	$\frac{5}{7}$	—	30 ×
8	—	16	—	480	(=20×24)	—	1	—	$\frac{1}{2}$	—	30
6	—	18	—	528	(=22×24)	—	1	—	$\frac{1}{3}$	—	29 ×
4	—	20	—	576	(=24×24)	—	1	—	$\frac{1}{5}$	—	28 ×
2	—	22	—	624	(=26×24)	—	1	—	$\frac{1}{11}$	—	28 ×

It should be remarked however, that many assayers of good authority use proportions of lead to alloy, considerably different from the above table, and the whole of the numbers here given may be considered as rather high in regard to the quantity of lead.

The German assayers observe the following rules.

Copper.		Silver.		Lead.
1.	with	30	requires	128
1	—	15	—	96
1	—	7	—	64
1	—	4	—	56
1	—	3	—	40
1	—	1	—	30
1	—	$\frac{1}{3}$	—	20
1	—	$\frac{1}{15}$	—	17

The proportions of lead required for gold assaying are nearly the same as for silver.

Assays of alloys of Platina.—On account of the great specific gravity of platina, it has sometimes been fraudulently employed as an alloy for gold, and being equally unoxidable by lead as gold and silver, it remains in the assay button after cupellation. It is not difficult however to detect this metal even in very small admixtures, and by the following marks. Gold alloyed with so little as 1 per cent. of platina, and cupelled in the usual way with 3 parts of silver, differs from gold and silver alone.

1. In requiring a much greater heat for compleat fusion of the button, especially at the last when all the lead is worked off, otherwise the button remains flat, like a piece of money, and its surface knotty.

2. Even when the button is well fused, its edges are much thicker and more rounded than in common gold assays, its colour more dull and tending to yellow, and especially it appears remarkably and entirely crystallized on its surface. This power of platina in giving a decided crystalline form to the gold or silver alloys in which it enters, is very characteristic.

3. In the cupellation, as soon as the last portions of lead are worked off, the button appears somewhat pasty, is scarcely iridescent, and especially it does not *lighten* or assume suddenly a brilliant metallic look, but remains dull and tarnished.

These appearances encrease with the quantity of platina in the alloy, but when it amounts to about 10 per cent. the colour of the alloy is so debased and whitened as readily to be distinguished from that of pure or standard gold, by simple inspection.

Silver is seldom alloyed with platina intentionally, the price of the two metals being so nearly the same as not to make it worth while as a fraud. When the platina is not more than 5 per cent. of the alloy, it works easily on the cupel, but the *lightning* is less observable than in a button of pure silver. But the remarkable property of crystallizing is still more conspicuous here than in the compound alloy of gold silver and platina, and the button is besides of a duller white, with somewhat of yellow. When the platina amounts to a quarter of the alloy, the button on the cupel flattens and becomes pasty, even before all the lead is run off; its surface becomes full of knobs, which by help of a glass appear clusters of crystalline points, and its colour is grey and tarnished.

The action of nitrous acid on the alloys of platina is very remarkable. By itself platina is insoluble in this acid as gold is, and an alloy of these two metals equally resists its action But when silver enters into the mixture in the same proportion as for parting (that is about 2 1-2 or 3 times the weight of the gold and platina) and when the platina is not more than about a tenth of the gold, the platina is totally soluble in nitrous acid, together with the silver, and the gold alone remains untouched.

On the other hand when an alloy of silver and platina alone is treated with nitrous acid, the silver dissolves as usual, but the liquor soon becomes muddy, with a very fine bulky black precipitate, which continues encreasing till all the silver is dissolved, and when collected is found to be entirely platina, comminuted by the acid, but scarcely changed in any other respect. A part of the platina however remains in perfect solution, for on adding to the liquor, separated from the black precipitate, some muriatic acid, white luna cornea falls down, after which carbonat of potash will throw down a green coagulum, which is oxyd of platina. The above effect of nitrous acid will therefore detect an alloy of silver and platina.

Gold alloyed with platina may be entirely purified (as we have just mentioned) by the process of parting with aqua-fortis, the alloy being as usual previously mixed with two or three times its weight of silver. Some peculiar circumstances are required in the operation. The mixed metal being laminated very thin and rolled into a spiral cornet, a weak acid is first added and boiled for some time. If the platina is above 2 per cent. of the gold, the acid assumes a straw colour, which deepens in proportion to the platina, and at the same time the cornets take a brownish green. A stronger acid is then added and boiled three times successively, to detach the last portions of platina, which are with difficulty separated, and by a magnifying glass may be seen adhering in minute grains to the surface of the gold cornet. Thus by laminating very fine, and by using the acid liberally, and long boiling, all the platina may be separated at one operation, when it does not exceed a tenth of the gold, and above that proportion the colour of the gold is so much debased, and the appearances on cupellation are so striking, that the fraud can hardly escape an experienced eye. Even if more than a tenth of the gold alloy, the platina may still be separated very completely by parting, but in that case more silver must be added, which will reduce the proportion of gold so much, that after the action

of the acid the comet can hardly be annealed without breaking down and losing its form.

ASTRINGENT (*Vegetable*). Till the later experiments on vegetable substances had shown the important distinctions between the tanning principle, and the acid, which from its being first extracted from galls has been termed the *Gallic*, that part of vegetables which has the power of tanning leather, and that which strikes a deep inky black with the salts of iron, were both confounded under the general term *astringent principle*, taken from the sensible quality of astringency to the tongue. They are now found to be totally distinct, and will be described respectively under the articles TANNING and GALLIC ACID.

ATTRACTION. See AFFINITY.

B.

BACON, the flesh of swine, salted, dried, and, generally, smoked in a chimney. As the history and customs relative to this savoury dish, would furnish but little instruction, we shall proceed to state the most approved methods of preparing it.

When a hog is killed for bacon, the sides are laid in large wooden troughs, and sprinkled all over with salt, mixed with a small quantity of nitre: thus they are left for twenty-four hours, to drain away the blood and the superfluous juices. After this first preparation, they should be taken out, wiped very dry, and the drainings thrown away. Next, some fresh salt, mixed with sugar or molasses, is to be rubbed over the meat, until it has absorbed a sufficient quantity, and this friction repeated six or eight successive days, while the meat is turned every other day. If large hogs are killed, the flitches should be kept in brine for three weeks, and, during that period, turned *ten* times, then taken out, and thoroughly dried in the usual manner; for, unless they be thus managed, it is impossible to preserve them in a sweet state, nor will their flavour be equal to those properly cured.

As the preservation of the salt used in this process, when carried on to a great extent, may be an object of economy, we shall state the following method of recovering the saline matter contained in these *drainings*, or in any other *brine*, whether from herrings, beef, or pork: it was communicated to us by a friend, who had seen it practised. He first added such a quantity of boiling water to the brine, or drainings, as was sufficient to dissolve all the particles of the salt. This solution he then placed in either an iron or earthen vessel, over a fire, which, by boiling, forced all the feculent and animal particles to the top, so that they were carefully removed by a perforated ladle. After the liquid had become clear, it was set aside for twenty-four hours, in a cool place, that the colouring matter might subside. But, as the combination it had formed with the boiled liquor was very tenacious, he contrived two different ways of separating it: 1. A solution of alum in water, one pint to an ounce of that substance, was gradually dropt into the cold liquor, in the proportion of a table-spoonful of the former to every gallon of the latter; and the whole allowed to stand for several hours; or, 2. If time and circumstances would permit, he filtered the liquor by means of long flannel slips, cut longitudinally by the web, but previously soaked in another strong and perfectly clear solution of salt: these slips were so immersed into the coloured fluid, that the projecting external end reached another vessel, which had been placed much lower than that containing the brine, or drainings. When these particulars were properly attended to, the absorbed liquor became almost colourless, and pellucid. Having thus procured a clear liquid solution, nothing more was required than to evaporate it to dryness, in order to re-produce the salt in its original granulated form. We have faithfully reported the process, which may be imitated without difficulty, and at little or no expense. In our opinion, the second method of discharging the colour is preferable, as, by this, no alum will be required, which only contaminates the salt.

Smoked Bacon.—The manner of preparing them is nearly as follows: after the hams have been properly salted, rubbed, and wiped with dry cloths, in order to absorb all the impure juices, the cavities of the joints, as well as the bones themselves, are carefully covered with a mixture consisting of two parts of the best salt, per-

fectly dried, and one part of black pepper, coarsely powdered. As soon as this operation is performed, the hams are, on the same day, suspended in a chimney or smoke house, where no other but wood fire is burnt, and which is usually increased during the first three days. The time of fumigation is regulated by the size of the meat, and generally extends from three to six months.

BAKING is the art of converting flour, or other farinaceous substances, into bread. As we propose to treat more fully on this subject, under the article BREAD, we shall here only explain what relates to a proper method of preparing it.

In private families, the baking of bread is frequently mismanaged; which may be ascribed to the following circumstances. Some women do not use a just proportion and temperature of water, so that the bread turns out either pasty, or too firm and heavy; others do not use a proper quantity or quality of leaven, or yeast, whence the bread acquires either an unpleasant bitterish taste, or the dough cannot rise, and consequently becomes tough and viscid; again, others do not understand the due degree of heat required in the oven, so that it will be either under, or over-baked. All these particulars deserve to be attended to, otherwise a bad and unwholesome bread will be produced. To survey, therefore, the whole process, which is one of the most complicated in chemistry, we shall here communicate a few general directions.

1. The flour, whether made of wheat, or rye, (which two are doubtless the best and most wholesome species of grain,) ought not to be used immediately on coming from the mill, as in a fresh state it is too moist for making good and palatable bread; but it should be kept in a dry place, for several weeks, stirred every day in summer, and at least every other day in colder seasons, till it has acquired such a consistence, as renders it loose and yielding between the fingers.

2. As the dough will not rise, without giving it a proper leaven or yeast, this ought to be a principal object in families, as well as to bakers. If leaven be employed, it should, on the preceding evening, be deprived of its hard crust, and dissolved with a little, scarcely milk-warm, water; then carefully mixed with about a third part of the flour to be used for baking, and kneaded into a soft dough, by adding more *tepid* water. A small quantity of flour is put on the top; and, thus prepared, it will be necessary to cover the trough with blankets, and suffer it to stand in a moderately warm place till the following morning, that it may rise and duly ferment. The remaining two-thirds of the flour must then be added, with a proportionate quantity of luke-warm water, and the whole kneaded into such an elastic dough as will draw into strings without breaking, and not adhere to the fingers. In this state it is again covered, and allowed to stand, (while preparations are making in the oven,) and not disturbed till it begins gently to rise, when it should be formed into loaves.

3. A proper degree of heat is an essential requisite to the baking process. When the inner arch of the oven appears entirely white, it is generally considered as sufficiently heated. But this being a fallacious criterion, we would recommend the following: Place a handful of flour before the aperture of the oven, and if it turn of a brown colour, the heat is then nearly of the degree required; but if it become black, or remain white, in the former case the fire must be considerably reduced; and in the latter, more fuel must be added. Lastly, all parts of the oven should be uniformly heated; and though we cannot enter into farther particulars, yet the attentive house-wife will easily, from her own observations, regulate the degree of heat, with the same effect as it might be done by Mr. Wedgewood's *Pyrometer* for the baking of earthen-ware.

Remark.—Musty flour, when baked into bread, is not only extremely detrimental to health, but it also imparts a bitter and nauseous taste. When such flour is not too strongly tainted, it may be corrected by first kneading it with leaven or sweet yeast, then making large holes with a wooden cylinder in the dough, filling up the cavities with flour that is perfectly sweet, suffering it to remain in this preparatory state till the next morning, then removing the dry flour carefully with long spoons or similar implements, and afterwards converting the dough into bread, with the addition of such flour as is not musty. By this simple process, the flour first mixed up will be sweetened, but that which has been left over night in the dough, is said to become so corrupted, as to be unfit for use.

It has frequently been attempted, and not without success, to bake good, wholesome bread, with little or no barm. In consequence of a dispute between the brewers and bakers of Dublin, concerning the price of yeast, in the year 1770,

the latter carried the point, by making their bread without it. As this process, however, could not be readily imitated in private families, we shall here state *a method of raising a bushel of flour with a tea-spoonful of yeast;* first practised by James Stone. It is as follows: Put a bushel of flour into the kneading-trough or trendle; take about three quarters of a pint of warm water, and thoroughly mix with it a spoonful of thick, sweet barm; then make a hole in the middle of the flour, large enough to contain two gallons of water; pour in your small quantity, and stir it with a stick, so that it may, with some of the flour combining with it, acquire the consistence of batter for pudding; then strew a little dry flour over it, and let it stand for about one hour, when you will find the small portion so raised, that it will break through the dry flour scattered over it. After this, pour in another quart of warm water, while you are stirring in more flour, till it becomes as thick as before; then again shake dry flour over it, and leave it for two hours longer. Repeat the same method about twice more, always suffering it to be somewhat longer at rest, and the bread will become as light as if a pint of barm had been used. Nor does this method require above a quarter of an hour more time than the usual way of baking; and the author of it asserts, that his bread has *never* been heavy nor bitter.

With respect to the difference of seasons, J. Stone directs that, in summer, the water should be used blood warm; in winter, or cold frosty weather, as hot as the hand can bear it without pain; while in the former season the dough should be covered up very warm, and strewed over with dry flour every time tepid water is added, to keep in the heat: after using six or eight quarts of such water to every bushel of flour, in the gradual manner before described, it will be found that the whole body of flour which is mixed with the warm water, by means of a single tea-spoonful of barm, is brought into considerable agitation, so that it waxes or ferments without difficulty. See also YEAST

BANK-FENCE, in rural economy, signifies the inclosure of ground with an artificial bank. In places where flat stones cannot be procured, the most durable and advantageous method of fencing in arable or pasture lands, is with turf or green sods, about five or six inches thick; the foundation five feet wide; the middle filled up with earth; the top about three feet broad, and planted with proper shrubs or dwarf-wood. As every agriculturist is acquainted with the manner of constructing such fences, we shall only remark, that they are in many respects preferable to the common hedges; because the latter, with their ditches, cover an almost incredible quantity of soil, while they neither afford sufficient shelter for cattle, nor can the herbage growing contiguous to them, be compared to that generally produced on the *sloping* sides of banks, where nettles and other aquatic weeds would not obstruct the vegetation of the more useful plants. It is, however to be regretted, that manual labour in this country is at present so very expensive, that few farmers, excepting those who hoard up their grain, and wait for the *maximum*, or highest price, are either inclined or able, to defray the first and unavoidable expence connected with the system of *bank-fencing*.

A subject of such extensive importance, we conceive, is entitled to every attention from a wise and economical legislature, or at least deserves to be conducted on similar principles, and with the same patriotic spirit, as has lately been displayed in the different schemes of inland navigation.

BANKS *of Rivers*, are those natural boundaries within which every stream is confined, according to the magnitude and velocity of its current. But as the course of rivers is frequently rapid and irregular, taking different directions, and often turning at acute angles, extensive inundations, especially in high spring tides, necessarily happen from the overflowing of their banks. Hence it is of the utmost importance to every inhabitant in the vicinity of rivers, to possess some knowledge of the proper method of forming embankments for the prevention of floods.

Although we cannot, consistently with our limits, attempt a full mathematical analysis, yet we shall lay down a few general hints, and maxims, by which the reader may be guided in the practical view of this subject.

1. The principal point to be ascertained, is the *elevation*, or the heights necessary to be given to such banks. This must be regulated by the additional quantity of water, which, according to former experience, the river brings down during its freshes; and likewise by the distance, at which the artificial bank is to be constructed, from the natural boundary of the stream. On this important point, mistaken economy frequently defeats its own purpose. If, therefore, the embankment is to be raised at some distance from the natural banks of the river, both a comparatively smaller height and base will be

required; the saving will be in the duplicate proportion of the former, and the works will be likewise the more durable, nearly in the same ratio; because, by enlarging the additional bed given to the swollen river, its velocity and power of ruining the works are, accordingly diminished. Unless, therefore, the freshes of the stream be loaded with fine sand, which might decompose the turf, the embankment should always be undertaken at a considerable distance from the edge of a river. By placing the artificial bank at half the breadth of the stream, from its natural banks, its channel will thus be nearly doubled, and the detached space, in general, afford excellent pasturage.

2. The next circumstance to be attended to, is, that the river will *rise higher*, when embanked, than it did at the time when it was suffered to overflow; and hence the difficulty of ascertaining to what height it may rise, from the greatest swell which has been observed in its former floods. For this reason, the utmost rise in some gorge, where the river could not extend farther, should be accurately marked, as far as can be remembered by the oldest inhabitants. Now the increased section in this place should be measured; and, as the water rises in a much greater proportion than the section, the latter must be increased nearly in the same proportion as the gorge already mentioned. Those who neglect this method of regulating the proper height of the embankment, by the greatest swell that has in former floods been observed in the plain, are in danger of constructing their banks too low, and consequently rendering them totally useless.

3. The whole embankment should, as much as possible, be conducted, in an *uniform line*, and by the concurrence of the proprietors of *both* banks; because the general effect to be aimed at, consists in rendering the course of the stream straighter than it was before. All bends should be made less abrupt, by keeping the embankment farther from the river in all convex lines of the natural bank, and approaching to it nearer, where the latter is concave. Thus the action of the waters on the embankment will be considerably diminished, and the duration of the work insured. On the same principles, we ought to proceed in fencing rivulets, or brooks, which empty themselves into a larger river; and whatever bends are given at its mouth to the two lines of embankment, they should always be made less acute than those of the natural brook; at the same time an opportunity should be taken of reducing the angle of this transverse brook, or, in other words, of conducting it with a more gentle flexion into the main river.

4. Particular care should be taken, to cover the *outside* of the dyke with compact pieces of turf, or green sods, closely united. For, if it admits the water, there is great danger of drenching the interior and more porous part of the wall, while the statical pressure of this fluid body tends to burst the bank on the land side; and thus the labour of months or years may be suddenly destroyed. Hence, too great attention cannot be bestowed on making and keeping it perfectly tight; so that the whole be one continued fine turf, and every bare spot must without delay be carefully covered with firm and fresh sods: nor should the rat and mice-holes be neglected.

Lastly, it deserves to be remarked, that a dry earthen bank, not firmly conjoined by grass-roots, will scarcely maintain itself against the pressure of the water with a slope of forty-five degrees, while a canal conveying a moderate stream cannot be supported, even with such a declivity. Those banks, however, the base of which is as four to three of their height, will stand without danger in a moist soil: and this is not only the slope usually given them, but also observed in the spontaneous operations of Nature, in the channels which she forms in conducting rills and rivulets through the higher and steeper grounds. This natural form possesses both mechanical and mathematical properties, which justly claim the admiration of those who adopt her beneficent hints and maxims.

The only method of keeping these impervious to water, is to *puddle* them. That is, when about two feet of the bank is built up on each side, let the intermediate space, amounting to three fourths of the whole width be made thus: Put in the common dirt or earth in the vicinity of it, to which add water enough to make it a fluid paste. Let this be well raked backward and forward by iron rakes with the teeth not much apart, constantly add to, and rake the whole of the middle part of the bank, till it is completed. On well and laborious raking of common earth, in a fluid state, depends the goodness of a bank. The sides may be sodded. When well raked, moles find it difficult to get through, but where moles are in a bank, they must be exterminated.

BARILLA, or BARILHA, is properly, the Spanish name of a plant cultivated for its ashes, from which the purest mineral alkali is obtained; but likewise sig-

nifies that particular sort of alkali which is principally imported from Spain.

There are four plants cultivated by the Spaniards for this useful purpose, namely, the *Barilla, Gazul, Goza,* and *Sqlicor.* But, as this account appears to be defective, we shall first present the reader with a list of those vegetables from which good barilla has been extracted in Britain; and next give a description of the most expeditious and profitable method of preparing this valuable material, for the various processes of washing, bleaching, &c.

Among the British plants, from which barilla or mineral alkali may be obtained, we shall at present enumerate the following, and then describe them in their alphabetical places:

1. Two species of the *Salsola,* of Linnæus, or SALT-WORT.
2. Two species of the *Salicornia,* L. or GLASS WORT, and SAMPHIRE.
3. The *Zostera Marina,* L. or GLASS-WRECK.
4. Two species of the *Triglochin,* L. or ARROW-GRASS
5. The *Chenopodium album,* and *maritimum,* L. or White and Sea GOOSE-FOOT.
6. The *Atriplex portulacoides,* and *littoralis,* L. or SEA-PURSLANE, and GRASS-ORACH.
7. The *Plantago maritima,* L. or SEA PLANTAIN.
8. The *Tamarix gallica,* L. or French TAMARISK.
9. The *Eryngium maritimum,* L. or SEA HOLLY.
10. The *Sedum Telephium,* L. or Orpine STONECROP, or LIVELONG.
11. The *Dipsacus fullonum,* L. or Manured TEASEL; and,
12. All the species of the *Cynara* and *Carduus,* L. or the ARTICHOKE and THISTLE, when cultivated either on the sea-shore, or in any soil irrigated with sea-water.

Barilla, as an article of trade, ought to possess the following properties; it should be firm, hard, and heavy, though porous; dry, and sounding on percussion; of a blueish colour, and impart, on breaking it, a flavour slightly resembling that of the violet. By these criteria, it may be easily distinguished from pot-ash, though it would be difficult to procure a barilla consisting purely of mineral alkali; as the very best sort of the former generally contains a small proportion of common salt. According to the experiments made by Mr. Kirwan, and published in the first volume of the *Transactions of the Royal Irish Academy,* in 1789, the barilla exported from Spain, contains carbonic acid, carbon, lime, clay, and silecious earth; but such as is very pure, also contains both common and Glauber's salt, and water. From the small quantity of carbonic acid discoverable in Spanish barilla, he concludes that its mineral alkali is for the most part combined with it in a pure or caustic state; and that its blueish colour must be ascribed to the matter of carbon: in a similar way, he attributes the green or blue colour of pot-ash to its combination with manganese.

This important article of commerce, is, in proportion to its degree of purity and strength, classed according to the following places, from which it is imported: 1. The barilla made at Alexandria; 2. That from Alicant; 3. Carthagena; and 4. Bourde, or Smyrna.

Various methods and schemes have excited the ingenuity of speculative men, in the production of this valuable substance. Those of our readers, who apply their attention to experiments of this useful nature, will, perhaps, be gratified by the following specification of Mr. James King's patent for his new-invented *British barilla,* granted in 1780. As his exclusive privilege is now expired, we shall communicate the process nearly in the patentee's own words. He first takes a quantity of ashes obtained from burning the loppings or branches of ash-wood, oak, beech, elm, alder, and any other kind of green wood and bramble, in the proportion of one-fourth; and a similar quantity of ashes obtained by burning the green vegetables, known by the name of fern, brecon, bean and pea-straw, and whin-ashes; also common field and highway thistles; the stalks of rape and mustard seed; and the bent, or rushes, that grow by the seashore. One half of the ingredients being thus procured, they are then passed through a fine sieve, placed on a boarded floor, and carefully mixed with a similar quantity (making the other half) of soap-boilers' waste ashes, which must be intimately blended together with a shovel. Next, he adds one hundred weight of quick-lime to twelve times that quantity of the other materials, and likewise intermixes them thoroughly. After this preparation, the whole is put into large square iron pans, and a sufficient quantity of sea-water is poured on it to dissolve the lime, ashes, &c. while the mass is stirred with an iron rake, to effect a more minute intermixture. A coal fire is now lighted under the pans, and kept briskly burning forty-eight hours, without intermission; at the same time,

the pans are continually supplied with sea-water, in order to impregnate these materials with a greater degree of the saline quality, till they acquire a proper consistence for calcination in a melting furnace, known by the name of *calcar*. This apparatus is constructed in the usual manner, except that there is a wall above the grate-room, to separate the fire from the materials laid upon the bottom. An intense degree of heat is used in this calcar, by means of which the saline mass boiled in the pan is completely dissolved, and afterwards kept in a state of fusion for one hour, during which time, the volatile part is expelled, and a fixed alkaline salt remains: this, being cooled in iron pans, produces British barilla, resembling that imported from Spain. Mr. King also declares, in the preamble to his patent, that this new chemical compound is calculated to serve as a substitute for manufacturing crown and broad window-glass, and also bottles, as well as for making soap and alum to much greater advantage, than any other material hitherto used in the production of those commodities.

Barilla is produced, by the incineration of different sea plants, chiefly in Spain and Italy, where whole fields are sowed with them by the farmers, to good advantage. From this impure and mixed mass of cinders, is obtained the marine alkali.

In Spain, Italy and France, it is also obtained from the fucus vesiculosus and from the salsola soda. The Saracens in Spain, called the plant which they used for the preparation of their Barilla, kali; which with the addition of the Arabian article, has given rise to the name alkali.

The discovery of the use of these plants, seems to be a present of the Saracens to the Europeans, for no mention is made of it, before the Mahometan æra. The Ancients seem to be silent on that head.

The manner of preparing these ashes, usually is thus: when the plant has attained its full height, they cut it down and let it dry; afterwards they burn and calcine it in certain pits, like lime kilns, dug in the ground for that purpose, which are covered up with earth, so that no air may come at the fire. The matter by this means is not only reduced into ashes, but by means of the salt juices united into a hard substance, which they break out of the pits with hammers.

The Spanish barilla is reckoned the best; and among the Sicily barilla, the preference is given to the produce of Utica, then comes that of Trapani, then Catanea, Marsala, &c.

In Sicily, the first crop of these herbs is cut in September and October; and they make a second crop about the end of November; but this second crop produces an inferior kind of barilla.

In shipping barilla, particular attention should be paid, to have as little small or dust as possible; as in the latter state it is most exposed to the access of air, which destroys its virtue. The marine alkali however, is less subject to attract humidity, than the vegetable alkali, like pot and pearl ashes, which can only be preserved when closely packed in casks. The usual assortment, in which barilla is sold in Sicily, consists of two thirds large lumps, one sixth small lumps, and one sixth dust. It answers best, not to ship any dust, but to resell it at half price.

Prime quality in barilla is to be distinguished, by its strong smell, when wetted with the spittle, and by its whitish color. If the lumps are hard, it shews they are fresh.

Barilla is used by glassmakers, soap-boilers, bleachers, and other manufacturers.

BARING OF TREES. See HORTICULTURE.

BARK, in the dissection of plants, is the exterior coat of trees, corresponding to the skin of animals. As these are furnished with a cellular membrane covering all the fleshy parts, and usually replete with white granulated fat, which can be liquified only by heat; so are plants surrounded with a bark abounding with oily juices, by means of which, nature has rendered them inaccessible to cold; because the spiculæ of the ice are prevented from fixing and freezing the fluids, which circulate through the vessels. Hence it is that evergreens continue their verdure at all seasons of the year, because their bark contains an unusual proportion of oil, more than is dissipated by the heat of the sun.

The quantity of bark on a tree may be increased by pinching off the flower-buds, as soon as they appear; but, if the former be wounded, by any accident, the edges of the dead rind ought to be carefully cut off, without injuring the living bark; and a mixture of white lead and boiled oil be applied, to preserve the wounded part from air, moisture, and insects—The following method of cure, which is stated to have been successfully practised where the bark of a tree had recently been torn off, we give on the authority of Dr. Darwin. It consists simply in again fastening the same piece of bark, or in tying down another piece from a tree, belonging to the same species; the edges of the wound

and bark being carefully adjusted; in consequence of which, the whole will combine in the same manner as the vessels of a scyon unite with those of the bark belonging to the engrafted stock.

The bark of plants is liable to peculiar diseases, as well as to be preyed upon by insects, which frequently prove destructive to the tree. One of its most common enemies is the *bark worm*, which infests and perforates its substance: and unless the parts affected be cautiously removed by the knife, and the superficial wounds plastered over with a mixture of wax and turpentine, (or Forsyth's Composition) the stem will in process of time become cankered, stunted in its growth, and ultimately fall a sacrifice to the disease.

M. Buffon has ascertained, by repeated experiments, that trees stripped of their bark the whole length of the stems, do not live longer than three or four years. It deserves, however, to be remarked, that, when thus deprived of the whole bark, and suffered to die gradually, they afford a more compact, heavy, and more durable timber, than if they had been felled in their healthy state. The reason of this improvement is obvious, as those oily and astringent fluids, which are secreted for the uniform nourishment of the bark, are absorbed, and deposited on the fibres of the wood, which, during the progressive dissolution of vegetable life, acquire what nature had provided for the supply of the external integuments. Yet there is one disadvantage arising from the privation of the bark, perhaps tantamount to the additional value of the timber, namely, that the farther increase, or growth of the tree, is for three or four years effectually checked.

The *barking of trees* ought, in our climate, to be performed in spring from about the middle of April to that of May; because at that time the circulating sap facilitates this operation, which, in dry seasons, is not only attended with additional labour, but the bark also will be of inferior value.

With respect to the *extent* of stripping the oak-bark from trees, a wide difference of opinion appears to prevail. Some owners of large tracts of wood, and great admirers of timber, cautiously prohibit the removal of the bark nearer than *six* inches to the ground; about which spot they suppose the tree to be felled: while others enjoin it to be done as near the ground as possible, provided that in this operation there be no part of the root laid bare. Mr. S. Hayes, the author of an excellent "*Practical Treatise on Planting*," published in England in 1796, inclines to the latter opinion: and adds, that the advocates for the former method would, on more accurate investigation, save themselves much unnecessary trouble, to little purpose, if not to their material injury.

The inner and more delicate part of the bark, especially that of the ash and lime trees, was used by the ancients, for writing and communicating their sublime ideas to posterity, prior to the invention of paper.

In economy, as well as in many of the practical arts, the utility of different barks is very great and extensive; for instance, that of the oak for tanning leather, and manuring the soil; the Peruvian cinnamon, quassia, willow-bark, &c. in medicine and for culinary uses; that of the alder and walnut trees in dyeing; and others again for a variety of purposes, such as the bark of the cork tree, &c. &c.—Without detailing the particular and curious processes adopted by foreign nations, for rendering the barks of various trees essentially useful, we shall briefly state, that the Japanese make their beautiful paper of the bark obtained from a species of the mulberry tree, called *morus;* the natives of Otaheite manufacture their cloth of the same tree, as well as the bread-fruit and the cocoa trees; the Russians and Poles produce their shoes worn by the peasantry, twist ropes, and form a variety of other useful articles, of the inner bark of the lime tree; the Germans have, for the last twenty years, converted the bark of the common black and white mulberry trees into excellent *paper*—An analytical account of the last mentioned article, interspersed with many new and curious facts, we propose to give in the sequel.

BARLEY. See AGRICULTURE, see also BREWING.

BASALT, or BASALTES, in natural history, a hard stone of a black, grey, or sometimes greenish colour; and on account of its constituent parts, and resemblance to *lava*, generally classed among the volcanic productions. It is remarkable, that this fossil is disposed either in solid or jointed columns; the former consisting of five or six pillars, either of an uniform size, or conical, and generally standing close to each other perpendicularly, of different, and sometimes equal length, as if they had been arranged by a skilful artist. The Hebridic island of Staffa is entirely composed of lofty and capacious basaltic columns, the most curious arrangement of which, perhaps, on the whole globe, is the celebrated Fin-

gal's cave. In Germany, also, there are several basaltic mountains; for instance, those on the Rhine, and near Freyberg, in Saxony, where basaltes is frequently found of an oval or spherical figure. Spain, Russia, Poland, and Silesia, also produce various basaltic rocks. Great quantities of this fossil are deposited in the neighbourhood of Mount Etna, in Sicily; of Hecla in Iceland, &c. But the largest mass yet discovered, are, what is called the Giant's Causeway, in Ireland.

As naturalists differ in their opinion concerning the origin of this curious substance, whether it be the production of volcanos arising from subterraneous fires, or derive its origin from crystallization by water, we shall state only the result of M. Bergman's inquiry into this subject, as his explanation appears to be conclusive. He asserts, that both fire and water contribute to form basaltes, and it cannot be doubted that there has been some connection between the basaltic pillars and subterraneous fire, as they are found mixed with lava, and other substances, produced by that element.

Uses—Basaltes is an excellent material for building houses, and paving streets: it is also employed by lapidaries and statuaries for various productions of art; as well as by artists working in gold and silver, for touch or test-stones.—Gold-beaters and book-binders, on the continent, make their anvils of this firm and massy stone; which is also used as an ingredient in the manufacture of glass, especially for producing the common window-glass, and green bottles.

From its being tougher and more durable than marble, it was a favourite material with the ancient Egyptian sculptors, many of whose works executed in basalt are at the present day in as perfect a state as when they were first finished. The cellular variety is used with some success as a material for millstones. It is also employed as a flux for certain iron ores. Basalt also when torrefied and pulverized, communicates to common mortar the property of hardening under water.

BASKET-SALT is made from the water of salt springs. It differs from the common brine-salt, in the fineness of the grain, as well as on account of its whiteness and purity. In preparing the former kind, some persons use *resin* and other ingredients, for separating the crystals, and reducing them to a smaller grain; others effect this by keeping up a brisk fire under the pans, and constantly stirring the salt; but the most approved method of manufacturing basket-salt is, to take out for this purpose, the third draught of every pan which is working for the common brine-salt; and to do this before the granules or crystals are perfectly formed.—Thus the salt will become very fine; and it is then hard pressed into small wicker-baskets, dried at the stove and kept for sale.

As there prevails, in many families, a prejudice against this species of salt, from an idea that some pernicious articles are used in the chemical process of preparing it, we advise those who are under the influence of such apprehension, to reduce common salt to powder, in a marble or iron mortar: but it requires to be previously cleaned or purified, by dissolving, and again evaporating it to dryness; in which state it may easily be pounded.

BAY-SALT, a kind of brownish impure salt, manufactured in France, Italy, and other countries, by evaporating sea-water in clay-pits; which is effected at a small expence, and with little trouble.

This salt is more or less adapted to all domestic uses, and forms a profitable article of commerce, as it is exported in large quantities. See SALT.

BEE, or *Apis*, in natural history, a genus of insects, of which the *mellifica*, or domestic honey-bee, is particularly worthy of attention.

1. *Economy*, *Instinct*, &c.

A hive of bees may be considered as a populous city, containing from fifteen to eighteen thousand inhabitants. This city is in itself a republic, where well ordered industry and perfect equality reigns. The combs are composed of pure wax, serving as a magazine for their stores, and a place to nourish their young. Between the combs there is a space sufficient for two bees to march abreast; and there are also transverse defiles, by which the bees can more easily pass from one comb to another.

Drones are larger than the working-bees; and when on the wing, make a greater noise. They sicken, die and are dragged from the hive, by the working-bees about the latter end of July.

Several kinds of *working-bees* were distinguished by the ancients. Columella coincides with Virgil, in preferring those which are small, oblong, smooth, bright or shining, and of a gentle disposition: the superior utility of this species has been established by experience. Working-bees compose the most numerous body of the state. They have the care of the hive; collect the wax and honey; fabricate the wax into combs; feed the young; keep the hive clean; expel all strangers; and employ themselves in promoting general

prosperity. The working-bee has two stomachs; one to contain the honey, and another for the crude wax.

II. *Of the management of bees*, and the most approved methods of preserving them, on removing their honey and wax.

According to Columella, an *Apiary* should face the south, in a situation neither too hot nor too cold. It should stand in a valley, that the bees may with greater ease descend, on their return to hive; and near the mansion-house, and situated at a distance from noise and offensive smells; and in the vicinity of a brook or river. Where the bees cannot have the benefit of running water, they ought to be supplied with it in a trough provided with small stones, on which they may stand while they drink. They cannot produce either combs, honey, or food for their maggots, without water; but the neighbourhood of rivers or canals with high banks, ought to be avoided, lest the bees should be precipitated into the water by high winds, and consequently perish. The garden in which the apiary stands, shoud be supplied with melliferous plants and branchy shrubs, that the swarms which settle on them may be the more easily hived.

Particular attention should be paid to the circumstance, that the bees be hived in a neighbourhood productive of such plants as supply them with food; such as thyme, the oak, the pine, fruit-trees, furze, broom, mustard, clover, heath, &c. Pliny recommends broom, as a plant particularly grateful and profitable to bees.

BEE-HIVES made of straw, have been generally preferred, as they are not liable to be over-heated by the rays of the sun, keep out the cold better than wood, and are cheaper than those of any other material.

M. Chabouille, in France, has lately suggested improvements upon bee-hives, which appear to us deserving of notice. His principal object is to procure the greatest degree of cleanliness for these delicate and industrious insects, by covering the bottom of the hive with plaster of Paris, and constructing the cylindrical inclosure of rye-straw, and cross ligaments, or bands, made of the inner rind of the lime-tree. When the basket-work is completed, he coats it over with a cement made of two-thirds of cow-dung, and one-third of ashes. In the interior part of the hive, he places two thin pieces of oak, crossing each other at right angles, which greatly facilitate the deposition of the honey-combs. The cover of the hive consists of a firm board, seventeen inches in diameter, and the entrance is so constructed, that it may be closed by a small door, to exclude injurious animals during winter. The lower part of this door has small semi-lunar incisions, each of which admits two bees abreast: above these, are made two rows of holes, just large enough for one bee to pass. The floor should be so constructed, that it may encompass and secure the foundation of the hive, to prevent any disturbance from that quarter. Such a smooth and white floor of gypsum, greatly contributes to cleanliness, and the bees become so much attached to it, that they will not easily relinquish their habitation. The straw-wall ought to be one-inch, and the cement before described, half an inch in thickness; the latter is the best coating yet contrived, for excluding noxious insects which would perforate the straw, and for sheltering the bees from rain and wind, while it exhales an odour very grateful to them. M. Chabouille has also observed, that bees kept in a hive of this description, are sufficiently protected against the effect of cold during winter; and that they swarm much earlier than those reared in any other.

However ingenious this contrivance may appear, we regret that the inventor has not stated the particular dimensions of the bee-hive, nor attended to many other circumstances relative to the culture of the insect itself. Hence we are induced to communicate a later, more accurate and circumstantial description of a bee-hive, invented in Italy by Professor Gaetano Harasti, which has proved of practical utility. This account is translated from the *Transactions of the Patriotic Society of Milan*, and as it contains much useful information on the subject, we have endeavoured to render it of practical service, by accompanying it with the appropriate cuts of the different figures described.

It is well known that bees, when properly cultivated, produce considerable profit, and in order to obtain the greatest possible advantage, it is necessary to supply them with every convenience for the support of themselves and their young. We should also contrive means to take the wax and honey with the smallest possible loss. In short, when the apiary is placed in a good situation, (either south or south-west,) that is, in a country abounding with flowers, at a distance from brew-houses, smelting works, &c. the next and most important point is the choice of well constructed hives.

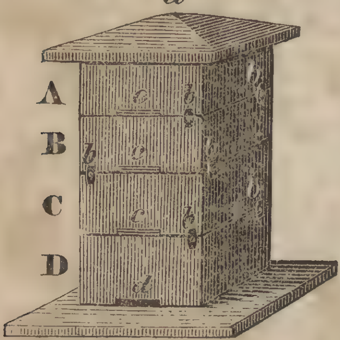
In Lombardy, the common hive, composed of straw, or twigs, is generally

used, though ill-contrived; as it is difficult to take away the wax and honey without destroying the bees.

Reflecting on these circumstances, M. Harasti, during his cultivation of bees, conceived that it would be possible to form a hive which should have all the advantages of the best kind, while the simplicity and cheapness of its construction, might bring it into use among husbandmen.

A good bee-hive ought to possess the following properties: First, it should be capable of enlargement or contraction, according to the number of the swarm. Secondly, it should admit of being opened without disturbing the bees, either for the purpose of cleaning it; of freeing it from insects; of increasing or dividing the swarm; or for the admission of a stock of provisions for the winter. Thirdly, it should be so constructed, that the produce may be removed without injury to the bees. Fourthly, it should be internally clean, smooth, and free from flaws. All these properties unite in the hive here described.

It is formed of four open square boxes, A, B, C, D, as represented by the following cut:



These boxes are fastened to each other by several wooden buttons, *b*, *b*, &c. which turn upon a nail or screw. The whole is covered with a moveable roof, which projects over the boxes slanting from the centre *a*, that the rain-water may run off. It is necessary to place a stone on the top of the roof, to keep it on firm.

Instead of buttons, the boxes may be combined by a rabbet fastened with wooden pegs: but in either case, the conjoined parts should be closed with cement. If the swarm is not very numerous, three, or even two, boxes will be sufficient. Each of them should be about three inches, or three inches and a half in height, and about six inches in the clear within. They should be made of wood, at least three quarters of an inch thick, that the bees, wax, &c. may be less affected by changes in the temperature of the atmosphere.

Within the boxes, at the upper part, there should be fixed two bars in the form of a cross, with the extremities extending to the angles of the box, as is represented in the following figure:

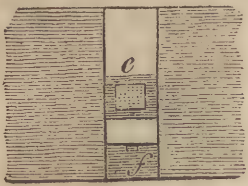
To these bars the bees attach their combs. At the lower part of each box, in front, there must be an aperture or door, as at *c*, *c*, *c*, *d*, as high as is necessary for the bees to pass conveniently, and about an inch and a half wide; of these apertures, only the lowest (marked *d*) is to be left open for the passage of the bees; the others are to be closed by means of a piece of wood, properly fitted to them.

It must be evident, that this bee-hive has all the advantages before mentioned. To lessen or enlarge it only requires a diminution or increase of the number of the boxes; and a communication with the internal part can easily be effected by the removal of the cover.

The cheapness and facility of the construction of this hive is evident, as nothing is requisite but to join four boards with nails, or in any other manner, so simple that it may be done by a day-labourer.

When the hives are made, they should be placed in a good situation: the best is south-west: but they must not be too much exposed to the heat of noon, which may be mitigated, by placing the branches of trees to shade the hives, as violent heat is injurious, not only to the bees, but to the wax and honey. The country around the apiary should be of a sandy soil, abounding with plants and shrubs. As bees love cleanliness and quiet, the circumjacent space should be kept clean, and free from offensive smells and noise: smoke is particularly disagreeable to them. The boards or table on which the hives are placed, should be dry, clean, and sound; and the hives ought to be sufficiently raised to prevent their ex-

posure to dampness and insects; they should also be kept at a distance from a wall, to avoid the reflected heat of the sun. In the table on which the hives are to stand, there should be an aperture, under each, about two inches square, as it is represented at *e*, in the following cut:



This aperture should be covered with a piece of tin, drilled full of small holes, so as to afford a free passage to the air, and at the same time prevent the ingress of insects. That this may not occasion any inconvenience to the bees in cold and damp weather, there must be a sliding piece of wood, *f*, under the tin, by which the hole may be completely covered.

When it is intended to introduce a swarm of bees into a new hive, it must be thoroughly cleaned, and the inside rubbed with virgin wax. It is advantageous to place a piece of clean honey-comb, about nine inches long, in the hive, and care should also be taken to choose that which is made of very white wax. This piece being supported by a stick passed through it, offers to the bees a kind of nest, and excites them to continue their work.

The new hive being thus prepared, the manner of introducing the bees into it, from an old hive, is as follows: the latter must be placed upon one of the boxes of the new one; but as it will seldom happen that they are of the same size, and exactly fit each other, a board, at least as wide as the largest of the two hives, and which has a hole equal in size to the smallest, must be placed between them, and completely joined with cement, or by any other means in such a manner as to be quite close, and to leave the bees no passage except into the new hive. As these insects generally work downwards, they will soon get into the new hive; and, when it is occupied by about one-half of the swarm, some holes must be made in the top of the old hive, and kept covered, till the proper time for making use of them.

Every thing being disposed as above directed, we must take the opportunity of a fine morning, but not a very hot one, about eight or nine o'clock, at which time most of the bees are generally out of the hive, gathering their harvest. The comb is to be cut through, by means of a piece of iron wire, and the old hive, with the board on which it stands, is to be separated from the new one. An assistant must immediately place the cover (already well fitted) upon the top of the new hive. The old hive is then to be taken away, to the distance of thirty or forty paces, and to be there placed upon two chairs, or other supports, in such a manner as to be quite firm; but leaving a free space, both above and below, for the following purpose.

Upon this old hive (the holes at the top of it being first opened) is to be placed one of the boxes of the new hive, having the cover loosely fastened on it, so that it can easily be removed; this box must be fixed upon the old hive, in such a manner (by closing the intervals between them with linen cloths, &c) that the bees, upon going out by the holes in the top of the old hive, can only go into the new one. In order to drive them into it, some live coals must be placed under the old hive, upon which a few linen rags may be thrown, to produce a great volume of smoke. As the smoke rises, the bees, being incommoded by it, will ascend to the top of the old hive, and at length will go through the holes into the new one. When all the bees, or nearly all, are gone into it (which may be known by looking in at the little door, or by their noise) it is to be removed gently from the old hive, and placed under the box already alluded to, the top or cover being previously taken off. The next morning, if it should appear that the two boxes, of which the new hive is now composed, do not afford sufficient space for the bees, a third box may be added, under the others; and after that a fourth, if necessary, as their work goes on, changing them from time to time, so long as the season permits the bees to gather wax and honey.

In performing the operations here described, it will be necessary to defend the hands and face from the stings of the bees. The best way of doing this, is to cover the whole of the head, neck, &c. (over a hat) with coarse cloth, or canvass, which may be brought as low as the waistcoat, and fastened to it: through this cloth we may see the operations of the bees, without fearing their stings. The hands may be protected by means of gloves, of which the best are those made of wool.

When we mean to bring a new swarm

into a hive, the one prepared as above, and formed of two, three, or four boxes, according to the size of the swarm, must be brought near the place where the swarm is. The upper box, with the cover fastened on (but so that it may easily be removed) must be taken from the others. The cross bars, before described, should be smeared with honey, diluted with a little water; the small door must be shut, and the box must be turned upside down, and brought under the swarm, which is then to be introduced, in the same way, and with similar precaution as into a common hive. When the whole swarm is in the box, it is to be carried to the other boxes (previously placed in their destined situation) and, turning it very carefully, is to be put upon them. The buttons are then to be turned, the interstices closed with the cement already described, and all the little doors closed, except the lowest, through which the bees are to pass. Nothing is more disagreeable to a fresh swarm than a hot sun, for which reason, that the bees may not wish to leave their new habitation, it will be right to shade the hive for some days.

But it is more advantageous to form artificial swarms, than to collect those which abandon their native hives, and the hive here described is very convenient for that purpose. The following method, M. Harasti conceives to be more simple, and more secure than any other hitherto proposed

Take a well-stocked hive, of four boxes, in some of these, particularly in the two lowermost, if they are well filled, there is certainly a young brood; for in these lower boxes the young bees are accustomed to change from the chrysalis to the perfect state, about the end of April, or beginning of May, if the hive be very full; but if otherwise, this change does not take place till towards the end of May, or even the middle of June. At that time, a fine serene day, but not excessively hot, must be chosen, and about eight or nine o'clock, the hive must be divided into two, in the following manner; Between the two upper boxes and the two lower ones, force in a few slips of wood, so as to separate the boxes sufficiently for the comb to be cut through with a piece of iron or brass wire. To prevent the bees from coming out through this opening, and thereby annoying the person employed in the operation, the smoke of tobacco may be blown (by introducing the small end of a pipe) into the opening; this will cause the bees to resort to the inner part of the hive, and will keep them quiet. But, if the hands and face are well covered, this precaution is unnecessary. An empty box must be in readiness, in the place where the hive is to stand: a cover must also be procured; and, as soon as the hive is divided in two parts, the two upper boxes must be taken from the lower ones, and the cover must be immediately put upon the latter, closing all the interstices with the usual cement. The upper boxes are to be placed upon the empty one just mentioned, so that a hive will then be formed of three boxes. The lower boxes, on which the fresh cover was put, must be left at rest till the evening, at which time a third may be placed under them; and when it appears that a proper quantity of work has been done in the lower box (of either hive) a fourth box may be added, under the others.

In the above manner, artificial swarms may be formed; and, by this method, we not only avoid the inconveniences which attend the procuring of swarms in the common way, but we obtain the advantage of having the hives always well stocked. This ought to be the first object of every one who cultivates bees; for it is allowed to be of more advantage to keep the hives well stocked, than to increase their number; and, in fact, it has been observed, that if a hive of 4000 bees gives six pounds of honey, one of 8000 will give twenty-four pounds.

Upon this principle, it is proper to unite two or more hives, when they happen to be thinly stocked. This may easily be done, by taking a handful of balm, and scattering it in those hives which are intended to be united. By this means, the bees will all acquire the same smell; and, it has been observed, that by the sense of smelling, bees distinguish those which belong to the same hive. After the above preparations, the hives are to be joined, by placing them one upon the other, in the evening, when they are at rest, taking away those boxes which contain few or no bees. Care must be taken to shut all the little doors, except the lowest.

It may even be proper sometimes to shut the lower door also, when, for instance, any tumult within the hive, causes the bees to endeavour to quit it. In such case, that the bees may not be deprived of air, a piece of tin, perforated with numerous holes, may be used to close the opening, instead of the usual door, and may be taken away when the bees become quiet.

The following is the method of taking the wax and honey, with little or no injury to the bees; but it should be previ-

ously remarked, that the honey is chiefly at the top of the hive, the young brood in the middle, and the greatest stock of wax is at the bottom. For this reason, when three of the four boxes are filled with comb, &c. the upper one A is to be first taken off, in the manner here described. The buttons *b*, *b*, &c. which serve to unite the boxes, are to be turned, or the wooden pegs (if such are used) taken out; the cement employed for closing the intervals is to be scraped off; and then a piece of iron wire is to be drawn through the comb so as to divide it. When the box A, is separated, its cover is to be taken off and put upon the box B, now become the highest. After taking out the contents of the box A, it is to be cleaned, and again placed upon the stand or table, under the box D, taking care to open its little door, and to shut that of the box D. To prevent any bees remaining in the upper box, when taken away, a little smoke may be introduced by means of a bellows.

The more empty space the bees find in the hive, the more eagerly they go to work. The brood of the box B, which remained at top, do not long delay to swarm, or at least they pass from the state of chrysalis into that of the perfect and laborious animal; therefore, when it is perceived that the lower part of the hive is occupied, the box B may be taken off, in the manner already described, and after being emptied, may be placed under A.

In the same way the third box C, in which there is generally a good stock of wax, may afterwards be taken off; but this is a matter of greater delicacy, because in general the eggs are deposited in it. We must also take care not to deprive the bees entirely of the stock of wax and honey which they have collected for the winter.

A hive made in the manner here pointed out, appears to me to be such as would be most useful to husbandmen in general, who wish to cultivate bees; but a hive may be made upon the same principles, which will shew the work of the bees, through its whole progress, and thereby enable any one to study the natural history of these wonderful insects.

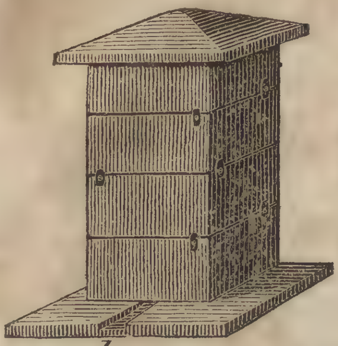
A hive of this kind is composed of three or four boxes, with a cover, like the hive already described; it may also be of the same form and size. But in every box, on that side which is opposite the little door, there must be fixed a pane of glass, with a sliding shutter over it, so that by drawing back these sliders, the inside of the hive will be exposed to view. To see the bees at work, however, it is necessary that the comb should be disposed in a regular manner, and perpendicular to the pane of glass. This may be obtained, by placing in the boxes, instead of the two cross-sticks already described, five parallel sticks or bars, as represented in the following figure:

The bees will attach their combs to these bars, and the intermediate space will afford sufficient light for seeing them work. If more light is desired, it may be obtained by opening the little doors opposite the glass; which doors may be made considerably higher than is above directed, and may have a slider over them, by which their aperture may be diminished at pleasure.

The sliders which cover the panes of glass, ought never to be opened, except for the purpose of observing the bees; because a strong light lessens their disposition to work. If it should be perceived that the coldness of the glass is prejudicial to the bees in winter, it may then be covered with a cotton cloth; or it may be entirely taken away, and a piece of paste-board put in its place; for at that time, the operations of the bees are suspended.

Instead of making a little door to each box, to be left open when the box is lowermost, for the passage of the bees, perhaps it might be better (because more simple) to cut a groove in the board or table on which the hive is placed. This groove should be about two inches wide, and about three fourths of an inch high at the outer edge, and should be gradually diminished, both in width and height, towards the part where it meets the hive,

as is represented at *b*, in the following figure:



b

Two advantages are derived from this construction. First, the little door in the box, and the contrivance for opening and shutting it, will be unnecessary. Secondly, it is sometimes proper to diminish or enlarge the opening for the passage of the bees, according to circumstances, without shutting it entirely; and this may be done with the greatest ease, by moving the hive nearer to, or farther from, the edge of the table; or this passage may be entirely closed, by moving the front of the hive beyond the groove: but in that case some small holes must be made in the hive to let in air, which may be stopped up when that formed by the groove is open.

A farther advantage attending this construction is, that as the groove will have a slanting direction, the bees will thereby be enabled, with very little trouble, to remove from the hive any dead bees, excrement, &c. which may be obnoxious to their nature.

Another very curious and useful bee-hive, is that originally contrived by Mr. Thorley, of London; which, from nearly sixty years experience, has proved of superior utility to any other. It is constructed as follows: the lower part is an octangular box, made of deal boards, about an inch in thickness, the cover of which is externally seventeen inches in diameter, but internally only 15½, and its height ten inches. In the middle of this cover is a hole, which may be opened or shut at pleasure, by means of a slider. In one of the pannels is a pane of glass covered with a wooden door. The bee-hole at the bottom of the box is about 3½ inches broad, and half an inch high. Two slips of deal, about half an inch square, cross each other in the centre of the box, and are fastened to the pannels by means of small screws. To these slips the bees fasten their combs. In this octangular box the bees, after swarming in the usual manner, are hived, and suffered to continue there, till they have built their combs, and filled them with honey; which may be known by opening the door, and viewing their works through the glass pane, or by the weight of the hive. When they have filled their habitation, a common bee-hive of straw, made either flat at the top, or in the common form, must be placed on the octangular box, and the slider drawn out; thus a communication will be opened between the box and the straw-hive, so that these industrious insects will fill this hive also with the product of their labours. When the straw-hive is sufficiently filled, the slider may be pushed in, and after placing another in its room, again speedily removed.

The Egyptian bee-hives are made of coal-dust and clay, which being well blended together, the mixture is formed into a hollow cylinder, about a span in diameter, and from six to twelve feet high: this is dried in the sun, and becomes so hard that it may be handled at pleasure.

Another, of a very simple and ingenious construction, has been invented by M. Degelieu. It may be made either of straw or wood: but, as its internal dimensions must be the same throughout its whole length, it is necessary that its form should be either cylindrical or prismatic. Its principal advantage is, that its bases are moveable, and may be fixed by pins at any distance from each other; by which means its size may be increased or diminished according to circumstances. It must lie on its side, and, in the foremost base, there must be a passage left for the bees. Hence, by drawing out the posterior base, the honey may be taken from the back part of the hive, without hurting the bees; and when this is done, the base should be pushed in close to the remaining comb, that an intermediate space may remain. By turning the hive, and making the entrance in that part which had before been the posterior base, the bees will build new cells, in the room of those taken away; consequently the honey will be whiter, and more pure.

Whoever intends to erect an apiary, should purchase hives towards the close of the year, when they are cheapest; and such only as are full of combs, and stocked with a sufficient number of bees. In order to ascertain the age of the hives, it

should be remarked, that the combs of the last year are white, while those of the former year acquire a darkish yellow. Where the combs are black, the hive should be rejected as too old, and liable to the inroads of vermin.

Bees never swarm till the hive is too much crowded by the young brood. They sometimes begin to swarm in May, or earlier, according to the warmth of the season. As soon as a swarm is settled, the bees should be immediately hived, to prevent their taking wing again. If they settle on a low branch of a tree, it may be cut off and laid on a cloth, the hive being ready for their reception; but if it be difficult to reach them, it will be advisable to let them remain where they have settled till the evening, when there will be less danger of their escaping.

When the swarm is hived, they should be immediately removed to the apiary, but the hive should be kept near the place at which the bees settled, till the evening, lest some stragglers might be lost.

The usual method of uniting swarms, is by spreading a cloth at night upon the ground close to the hive in which the two swarms are to be placed. Lay a stick across the cloth, on which place the hive with the new swarm: on giving a smart stroke on the top of the hive, all the bees will drop in a cluster upon the cloth. Then take another hive from the stool, and place it over the bees, when they will ascend into it, and mix with those already there. Another method is, to invert the hive in which the united swarms are to live, and strike the bees of the other hives into it, in the manner before described.

A large swarm weighs eight pounds, and others gradually less, to one pound. Hence a good swarm should weigh five or six pounds. Such as are less than four pounds weight, should be strengthened by a small additional swarm. The size of the hive ought to be proportionate to the number of the bees, and it should be rather too small than too large, as these insects require to be kept warmer than a large hive will admit.

Great improvements may be made in providing plenty of pasture for bees; and as a rich corn country is unfavourable to their industry, the practice of other nations, in shifting the abode of their bees, is deserving of imitation.

M. Maillet, in his description of Egypt, informs us, that the natives of that fertile country annually send their bees into distant regions to procure sustenance for them, when they cannot find any at home. About the end of October, the inhabitants of Lower Egypt embark their bees on the Nile, and convey them to Upper Egypt, when the inundation is withdrawn, the lands are sown, and the flowers are beginning to bud. These insects are thus conducted through the whole extent of Egypt, and, after having gathered all the rich produce of the banks of the Nile, are reconducted home about the beginning of February.

In France, floating bee-hives are very common. One barge contains from sixty to a hundred hives, which are well defended from the inclemency of the weather. Thus the owners float them gently down the stream, while they gather their honey from the flowers along its banks; a single bee-house yields the proprietor a considerable income.

Their method of transporting bees by land, is also worthy of our attention. The hives are fastened to each other by laths, placed on thin pack-cloth, which is drawn up on each side, and then tied by a piece of pack-thread several times round their tops. In this state they are laid in a cart, which generally contains from thirty to fifty hives, and conveyed to places where the bees can collect honey and wax.

During the winter, bees are in so lethargic a state, that a little food is sufficient for their sustenance: but as every sunny day revives, and prompts them to exercise, food is necessary on these occasions. Some hives of bees, which are supposed to have died of cold, have in reality perished by famine, especially when a rainy summer prevented them from collecting a sufficient store of provision. Hence the hives should be carefully examined in autumn, and ought then to weigh at least eighteen pounds each.

With respect to the feeding of bees, the common practice is, to leave them as much honey in autumn as will make the hive weigh twenty pounds. The honey should be diluted with water, and put into an empty comb, split reeds, or upon clean wool, which the bees will suck perfectly dry. By the dilution with water, however, the honey is apt to become candied, in which state it is prejudicial to the bees. A better method is, to replenish the weak hives in September, with such a portion of combs filled with honey taken from other hives, as may be deemed a sufficient supply. This is done by turning up the weak hive, cutting out the empty combs, and placing full ones in their stead, secured by pieces of wood, that they may not fall down when the

hive is replaced. If this method be considered too troublesome, a plate of honey, unmixed with water, may be placed under the hive, and straws laid across the plate, covered with paper perforated with several small holes, through which the bees will suck the honey without difficulty.

The degree of cold which bees can endure, has not been ascertained. In the cold parts of Russia, they are often found in hollow trees. Their hives are frequently made of bark, which does not afford them much protection. Hence, Mr. White observes, that bees which stand on the north side of a building, will not consume more than one-half of the honey necessary to supply others which stand in the sun. In winter, however, they should be examined; and if, instead of being clustered between the combs, they are found in numbers at the bottom of the hive, they should be carried to a warmer place, where they will soon recover. In winters extremely severe, lay on the bottom of an old cask the depth of half a foot of very dry earth, powdered, and pressed down hard. On this, place the stool with the hive; and, to preserve a communication with the air, cut a hole in the cask, opposite to the entrance of the hive, in which fix a piece of reed, or hollow alder, and then cover the whole with dry earth.

In England it is usual, in taking the honey, to deprive the bees of their lives. The common method is, to suffocate them with the smoke of brimstone; but Mr. Manley has adopted a more humane and judicious plan: he says, "I never destroy the old stock of bees; but after lifting them, to examine what honey there is, if I think the hive is full, I put another under it with a flat top, having a square hole in the centre. When the bees are in the under hive, I place a shutter, which is of wood, in the hole at the top; and that prevents them from going into the upper hive. I then invert it in a bucket, and strike it with a rod till I think they are all out, after which they go into the under hive."

Mr. Wildman gives the following instructions for taking the honey and wax. Remove the hive into a darkened room, that it may appear to the bees as if it was late in the evening; then gently invert the hive, and place it between the frames of a chair, or any other steady support, and cover it with an empty hive raised a little towards the window, to give the bees sufficient light to guide their ascent. Hold the empty hive, steadily supported, on the edge of the full hive, between the left side and arm, and continue striking with the right hand round the full hive, from the bottom upwards, and the bees, being frightened by the noise, will ascend into the other. Repeat the strokes, rather quick than strong, round the hive, till all the bees are gone out of it, which will be in about five minutes. As soon as a number of the bees have got into the empty hive, it should be raised a little from the full one, that they may not return, but continue to ascend. When they are all out of the full hive, that in which they are must be placed on the stand, to receive the absent bees as they return from the fields.

The combs should be cut from the sides and top as clean as possible, to save the future labour of the bees. During this operation, the hive should be placed, reclining to the side from which the combs are taken, and afterwards put for some time upright, that the remaining honey may run out.

Having finished the taking of the wax and honey, the next business is to return the bees to their old hive, for which purpose we must refer the reader to the directions already given, when we stated the usual method of uniting swarms.

By inverting the hive which contains the bees, and placing their own over it, they will immediately ascend, especially if the lower hive be struck on the sides to alarm them.

With regard to the increase of bees, Mr. Hubbard, of Bury St. Edmunds, England, advises the owner to wait with patience, until he has acquired twenty stocks, and in the month of April to separate ten of the strongest hives for swarming; the other ten must be raised on large empty hives, the tops of which should be previously taken off, and the joinings of the two hives secured with a little clay, which plan prevents the bees from swarming. He also recommends the prime swarms from the other stocks, to be put into three-peck at least: for, when they appear very early, they will probably swarm again in a few weeks, which should always be prevented, and all the after-swarms be united, two or three into one; for the great advantage arises from a large quantity of bees being kept together; and, by that mode, ten stocks will generally yield fifteen good ones.

The following observations were published by George Morgan, Esq. formerly of Princeton, New Jersey.

"Several writers on the management of

bees, have given very ingenious directions for taking their new made honey, without destroying those useful creatures. My humanity, hurt at the idea of setting fire to the fatal match, induced me to imitate their methods; particularly those of Mr. Wildman, and the Rev. Mr. White, whose directions I observed very attentively, with some success; but my expectations were not gratified, as I found young broods in every hive I took, and consequently the honey obtained was impure. However, after a variety of experiments, I discovered an agreeable, safe, and easy way to take the honey, without the least injury or disturbance of the bees.

As I have experienced great pleasure, and some benefit from my discovery, I take this opportunity to lay it before the Agricultural Society.

My boxes are made after the manner of Mr. White's, of any well-seasoned wood, ten inches square in the clear; in pairs, with communications at the sides, for the bees to pass freely from one box to another: a pane of glass (7 by 9) with a sliding shutter, may be put into the back part of each box, through which you may see the bees at work. Any person who can handle a saw and hammer, may make the boxes at a small expence.

The communications between the boxes are at top and bottom; those at top should be three inches long, and half an inch wide, to serve as streets or alleys betwixt the hives.

The communications at bottom should be five or six inches long and three fourths of an inch deep, so as to afford a free passage from one hive to the other.

The mouth of the hive may be from three to ten inches long, and half an inch deep. In the busy season, this wide entrance facilitates the bees going out and coming in, and may be contracted at pleasure in autumn.

Early the next morning after hiving a swarm of bees in one of these boxes, I add another to it, the door of which I close until the bees begin to work in it; when I open it to facilitate their industry.

Each box, of the above dimensions, will contain thirty pounds of honey. An early swarm, in a favourable situation and season, will fill two boxes, and cast out several swarms; each of which will fill two boxes with honey.

As winter approaches, all the bees collect themselves into one box, and will leave the other, with its contents, to the use of the owner, whose profit, in good seasons, will be 90lb. of honey, and several additional swarms, for every stock kept over the preceding winter—15 or 20lb. of honey are sufficient to keep a stock over our longest winters, but I leave them 30lb.

Thus I acquire the purest honey, without the use of the match, or any trouble in dividing or disturbing the bees; for on turning up the hives (which have no glasses) I discover, immediately, that in which the bees are collected, and I carry off the other, without a single bee in it.

The losses and disappointments I have met with in a great variety of experiments, induce me to recommend this management to every lover of bees, as I have found it easy, pleasant, and profitable."

It ought to be observed, that all honey is not wholesome. Bees indiscriminately sip the flowers of all plants abounding with sweets; and as some of these plants are of a poisonous nature, it follows that the honey must partake of their injurious qualities. Dr. Barton has written a very excellent paper on this subject. *Amer. Phil. Trans.* vol. 5th. The plants affording this poisonous honey are, *kalmia angustifolia*, or dwarf laurel; *kalmia latifolia*, or great laurel; *kal. hirsuta*, a pretty little shrub of the southern states; *andromeda mariana*, or broad-leaved moorwort. As these are very plentiful in many of the American forests, their blossoms afford much honey for the wild bees.

Dr. B. thinks that it will be found that other plants yield unwholesome honey; such are, 1. *Rhododendron maximum*, or Pennsylvania mountain laurel; *azalia nudiflora*, or wild honey suckle; and *datura stramonium*, or James-town weed. The four first mentioned plants ought to be extirpated in the neighbourhood of bee-hives; and the honey procured from the three enumerated in the second place as suspicious, should be carefully examined to determine the fact with regard to them.

The manner of treating bees in Portugal, is as follows: A spot of ground is chosen for the hives, exposed towards the south or south-east, well sheltered from the northern blasts, and surrounded with shrubs and flowers; of the latter, rosemary is preferred. The richer the neighbouring grounds are, the better; for bees are said to range for food to the distance of a league from their home. Lanes are cut through the shrubby thickets, of five or six feet wide. The fences between the lanes are about the same dimensions, and formed at intervals into small recesses, like bowers or niches, to receive the hives.

With respect to the *Diseases of Bees*, we shall mention a few hints, extracted from the above-mentioned work.

Bees are sometimes afflicted with a diarrhœa, in consequence of feeding greedily on the blossoms of the milk-thistle,

and elm. The best cure is, pounded pomegranate seed and honey, moistened with rich, sweet wine; or raisins mixed with similar wine or mead, in which rosemary has been boiled. When they are infested with vermin, the hive must be cleansed, and perfumed with a branch of pomegranate, or the wild fig-tree, which will inevitably destroy the vermin.

Butterflies are said to conceal themselves in the hives, and annoy the bees: these intruders may easily be exterminated, by placing lighted candles in deep tin pots between the hives; as the flame will attract them, and conduce to their destruction

In order to extirpate hornets preying upon the honey, it is only necessary to expose shallow vessels near the hive, with a little water; to which these predatory insects will eagerly repair, to quench their thirst, and thus easily drown themselves.

To prevent bees of one society from attacking or destroying those of another, Dr. Darwin recommends a board, about an inch thick, to be laid on the bee-bench, and the hive to be set on this board, with its mouth exactly on the edge; the mouth of the hive should also be contracted to about an inch in length, and a semi-circular hollow made in the board, immediately under the mouth of the hive. By this simple method, the assailing bees will be constrained to act with great disadvantage.

If, however, this should not succeed, Dr. Darwin advises a removal of the bee-hive to a distant part of the garden, and to a more easterly aspect; as he has from experience observed the good effects of such a change. This acute philosopher farther observes, in his admirable *Phytologia*, when treating of the glands and secretions of vegetables, that the depredations of insects committed on that nutritious fluid, *honey*, is probably injurious to the products of *vegetation*; and that some plants are more exposed and accessible to bees than others, which are either better defended, or secrete a greater portion of honey than is necessary for their own economy. Of the latter description are, the catch-fly, sun-dew, hellebore and aconite: of the former, the Doctor mentions the *Polygonum melampyrum*, or Buck-wheat, and the *Cacalia suaveolens*, or Alpine Colts-foot; in both of which there also appears to be a superabundant quantity of honey secreted. The flowers of the two last-mentioned plants are perpetually loaded with bees and butterflies; insomuch, that at Kempton-land, in Germany, Mr. Worlidge says, in his *Mysteries of Husbandry*, chap. ix. 3, he saw forty great bee-hives filled with honey, to the amount of *seventy pounds each, in one fortnight*, by their being placed near a large field of buck-wheat in flower: and Dr. Darwin adds, that he well remembers having seen an astonishing number of bees on a field of buck-wheat in Shropshire, as well as on a plant of the Alpine Colts-foot in his garden; from which the scent of honey could be perceived at several feet distance from the flower.

To conclude this interesting subject, we cannot omit the judicious remarks of a veteran writer, Dr. J. Anderson, whose numerous and useful works, in every branch of rural and domestic economy, are of inestimable value to the farmer. In one of his practical papers *On the Management of the Dairy*, communicated to the Bath and West of England Society, he observes in a note, that bees, in this variable climate, are a very precarious stock, though extremely profitable where they thrive. During the frequent mild days of winter, and the warm mornings of spring, which are suddenly succeeded by a nipping frost, or sleety rain, these creatures are roused from their torpid state; and, being unable to obtain food abroad, they are obliged to consume and exhaust their stores, and perish from want. And as the warmth of the weather in spring invites them to search in vain for flowers affording them nourishment, they are often chilled by cold, before they are able to return to the hive. To prevent such fatal accidents, Dr. Anderson is of opinion, that no method would be so effectual as that of placing the hives in an ice-house, at the approach of winter. Here they may be kept till the spring has so far advanced, that no danger is to be apprehended from bad weather. During the whole winter, they will remain in a state of torpor, and require no food. As soon as the mild weather incites them to appear, they will commence their labours with vigour. The intense degree of cold which the bees sustain, without the least injury, in Poland and Russia, where even quick-silver is sometimes frozen, removes every doubt, or anxiety, concerning the safety of bees in an ice-house.

BEES-WAX. See Wax.

BEECH-MAST OIL, is expressed from the mast, or nut of the Beech tree, after it has been shelled and pounded. It is used in many parts of France and Silesia instead of butter; according to some accounts, it is little inferior to oil of olives. After the oily part has been extracted, the remainder of the mast, when dried, is said to be sweeter and more palatable than before, and may be easily converted into flour, of a similar taste and colour to that of wheat.

In order to obtain pure oil, the following circumstances must be attended to: 1. The fruit must be carefully selected, and all musty, rotten, or tainted nuts, particularly those of the former year, should be rejected.

2. The shell of the nut should be taken off, which is necessary not only for increasing the quantity, but also for improving the quality of the oil, because the husk communicates a particular flavour.

3. The film which surrounds the kernel should then be removed, an operation which is essential to the perfection of the oil and the flour; for the film, though small in quantity, has an astringent disagreeable taste, which is plainly perceptible in both the oil and the flour, where its removal has been neglected. It may be separated by putting the kernels into hot water, as is practised in blanching almonds.

4. After the nuts are gathered, they should be preserved for two or three months in a dry place, so thinly spread out as not to allow them to heat, and often turned, to keep them sweet; then bruised like apples in a cyder mill. In this state the mass should be put into bags of strong thin canvas, and pressed cold. The oil must be extracted by three degrees of pressure: the first moderate, which gives the purest and finest oil; the second harder, which yields it of an inferior quality; and the third as forcibly as the materials will bear, from which an oil of an indifferent quality is obtained. After each separate pressure, the bag should be turned, and the mast, after being well shaken, may be preserved for use.

It has been asserted, that the mast, though three times pressed, is more nutritive than in its natural state. It may, therefore, not only be given as a wholesome food to poultry, swine, and oxen, but also be manufactured into hair-powder. Se an interesting extract from a paper in the *Memoirs of the Royal Academy of Sciences in Paris*, on beech-mast oil, in Dr. Anderson's recreations, vol. 2d.

BEEF, the flesh of cattle, prepared for food. This process is managed in various ways, accordingly as the meat is intended for keeping a longer or shorter time. The usual method of salting beef, being generally known, we shall refer to the article "BACON," and briefly observe, that much depends, 1. On the purity and quantity of the salt used for this purpose; 2. On the size of the pieces, and the nature of the vessels in which they are kept; and 3. On the ingredients which may be employed with a view to assist the operation of the salt.

It is an established fact, that salt proves antiseptic only when used in a considerable quantity; and that a *weak* brine strongly tends to hasten the putrefaction of animal substances: hence the necessity of making a liberal use of this article. On the other hand, as common sea-salt contains a very considerable proportion of *magnesia*, one of the most absorbent earths for promoting putrefaction, it is attended with great inconvenience to those who are obliged to make use of large quantities of such salt; because it is difficult to separate that ingredient from this concrete.

Hence *rock-salt*, though apparently more impure, is doubtless more advantageous, and proper for the curing of beef; because its crystallization has been accomplished by Nature, probably after the more earthy base, or magnesia, had in a great measure, spontaneously subsided. We offer this as a mere conjecture; as it is of little importance to the economist, how this combination of salt and putrefactive earth has originally taken place, if we can suggest a method of purifying the former, so as to render it fit for the purpose intended: See SALT. At present, however, we shall treat first of the manner which, by experience, has been found the most effectual for salting, preserving, and imparting a fine flavour to beef, mutton, and pork. For this useful information we are indebted to M. Schedel, who has inserted the following recipe in the "*Economical Journal*," for September, 1795, printed at Leipzig: Take four pounds of common salt, one pound and a half of refined sugar, two ounces of salt-petre, and two gallons of pure spring water. Boil the whole over a gentle fire, and carefully scum off the impurities. After this brine has become cold, pour it over the meat, so that every part of it may be completely covered. In this preparation, the meat not only keeps for many months, but the pickle also has the effect of softening the hardest and toughest beef, and rendering it as mellow as the flesh of chicken. But, in warm weather, it will be necessary to express the blood from the meat, and to rub it well with fine salt, before it is immersed in the liquor. Young pork should not be left longer than three or four days in this brine, during which time it will be sufficiently softened; but hams intended to be dried, may lie in it a fortnight, before they are suspended. At that period, they ought to be rubbed with pollard, and covered with paper bags, in order to pre-

vent them from becoming fly-blown. It farther deserves to be remarked that, though this liquor is more expensive at first than the common brine, yet as it may again be used after boiling it, and adding more water with a proportionate quantity of the other ingredients, its relative utility is obvious.

The superiority of the receipt commonly known by the name of Adml. Pocock's, is so well known to those, who have had an opportunity of comparing it with others, that it ought to be generally adopted. It is thus made. Water four gallons, Muscovado sugar or molasses a pound and a half salt (the bay or large sort) six pounds. Boil all together in an iron pot, or kettle, and skim it repeatedly, as long as any scum rises; then take off the pot to stand till the liquor is cold. The meat being placed in the vessel meant to hold it, pour the cold pickle on the meat, till it is covered; and, in that state, keep it for family use. If the meat is to be preserved a considerable time, the pickle must be boiled once in two months; skimming off all that rises, and throwing in, during the boiling, two ounces of sugar, and about half a pound of common salt. Mr. Bordley, says, the above pickle "is incomparable, also, for curing hams, tongues, and hung-beef. When tongues and hung-beef are taken out of the pickle, clean and dry the pieces; then put them in paper bags, and hang them up, in a dry warm place. In very hot weather, it is necessary, before the meat is put to the pickle, to rub it well over with salt, and let it lie for one, two, or three hours, till the bloody juices run off. If the meat in this case be in the least tainted, before it is put to the pickle, it will be entirely spoiled in a day's time in hot weather.

Mr. Bordley recommends, to keep beeves intended to be killed, two days from food and drink; and, in a dark and close place. He thinks, the animal bleeds better, handles lighter and cleaner; and, that the meat looks better by observing these directions. The barrels are to be ready, sweet and well trimmed, and the salt previously washed or refined, and ground small, before the beeves are to be slaughtered. Delay in salting is injurious. The pieces are, therefore, to be packed into the tight barrels, piece by piece, as they are salted; instead of bulking them on a frame, or dresser to drain, as is the practice. Coarse salt washed but not ground, having also been previously ready, is to be dissolved in fair cold water, until no more can be dissolved on stirring. Let it settle a day, or two, skim off the top, pour off all but the dregs. When perfectly cool and clean, it is ready to be poured on the repacked beef. After the meat has remained in the barrels six or eight days, headed up tight, it is to be taken out, resalted, and closely repacked in the same barrels; the drainings are to be preserved and boiled: the barrels are then to be headed up. In a few days, bore a hole in one of the heads, or bilge of each barrel, and fill the barrels with the prepared and boiled juices of the meat, saved from the first salting and barrelling. Every time of filling, the barrels being rolled, leaves room for more liquor. When there is no more of the prepared liquor, the barrels are next to be repeatedly filled with the plain strong brine made as above, from the washed coarse salt, till they can take no more, after standing a short time. Here, as in preserving fish in barrels, the operations are distinctly to *salt* and to *cure*, and the boiled juices from the salted meat, must serve to beef what the pickle of fish cured is to herrings. On boiling the blood and juices with the pickle, the firmer parts settle in a mass on standing, and the liquor pours off clean.

The barrels ought not to be exposed either to the sun, or to damp. A cool dry place is best.

Attention to the kind of salt used in salting meats, is of more consequence than is generally imagined. The Hollanders who furnish the world with the finest flavoured herrings, (caught on the coast of Scotland,) and derive an immense revenue from the trade, prevent by law the use of all kinds of salt in the herring business, except that from Portugal or Spain. It would be well to attend to this circumstance in this country.

As to the properties of beef, in general, we shall only say, that it affords a good, strong, and invigorating nutriment, because no animal food is equal to the flesh of a healthy, middle-aged bullock. Plethoric persons, however, as well as youth, in whom there is naturally a disposition to generate heat, should eat beef in great moderation.

BEER is a fermented, spirituous liquor, prepared from any farinaceous grain, but generally from barley; and strictly speaking, is a vinous production, serving as a substitute for wine.

As we propose to give a short analysis of the art of *Brewing*, under that head, we shall here only observe, that all kinds of beer are produced by extracting a proportionate quantity of malt, whether made of wheat, barley or oats, in boiling wa-

ter; then suffering it to remain at rest, in a degree of warmth requisite to induce a vinous fermentation, and afterwards managing it in the manner as will be described under the article just mentioned.

Although malt alone might doubtless produce a liquor possessing the spirituous properties of beer, yet such a preparation would speedily turn sour and insipid, unless impregnated with hops, or another aromatic and bitter principle, derived from vegetable substances, which not only render it less liable to undergo the putrefactive stage of fermentation, but also impart to it an agreeable bitterness. Of this nature is the hop in a very eminent degree, the price of which, however, has of late years been so exorbitant, that speculative brewers have substituted a variety of other vegetable ingredients, and especially the wood, bark, and root of *quassia*. Independently of the inferior price of this drug, when compared to the indigenous hop, there can be no reasonable objection to its use; as it is one of the few astringent substances possessing a considerable share of the bitter principle, without partaking of the narcotic, heating, and intoxicating properties of other plants.

It would be difficult to lay down an accurate criterion of the best and most wholesome beer; as its relative strength and flavour, or the immediate effect it produces on the palate, are generally considered the most essential requisites. But a well-brewed and wholesome beer, whether ale or porter, ought to be of a bright colour, and perfectly transparent, that is, neither too high nor pale; it should have a pleasant and mellow taste, sharp and agreeably bitter, without being acrid or tart; it should leave no particular sensation on the tongue; and, if drunk in any considerable quantity, it must neither produce speedy intoxication, with its concomitant effects of sleep, nausea, vomiting, head-ach, langour, want of appetite, &c. nor should it be retained too long in the urinary passages, or be too quickly discharged.

Dr. James Stonehouse, of Northampton, inserted the following recipe for making *Beer* of *Treacle*, in the *Gentl. Mag.* of January, 1758: "To eight quarts of boiling water, put one pound of treacle, a quarter of an ounce of ginger, and two bay-leaves. Let the whole boil for a quarter of an hour, then cool and work it with yeast, the same as other beer:" or, "Take one bushel of malt, with as much water and hops as if two bushels of malt were allowed; put seven pounds of the coarsest brown sugar into the wort, while boiling. This makes a very pleasant liquor; is as strong, and will keep as long without becoming sour or flat, as if two bushels of malt had been employed."—Dr. Stonehouse adds, that the latter is the preparation used in the Shrewsbury Infirmary, and he does not hesitate to attest its wholesome and nutritive properties.

Extemporaneous small beer. To two quarts of common porter, add of molasses half a pint, of ginger two drachms, water just warm, four quarts; let the whole ferment in a warm place, then rack off.

Another. Lemon Peal, one ounce, Cream of Tartar four ounces, hops one ounce, molasses one quart, ginger one drachm (sixty grains) bruised cloves four in number, boiling water four gallons; ferment with yeast.

Another.—To ten bottles of hot water, add one bottle of porter, and one pint of molasses, stir them well together and bottle them for use.—It will be fit to drink in a few days.

Beer, (Spruce.) To a four ounce gallypot of essence of spruce, add three quarts of molasses, two gallons of warm rain water, and half a pint of good yeast. Stir them well together until the liquor bears a froth, then put it into the cask and fill it with nine gallons of water, shaking it well. Set it aside for two or three days to ferment with the bung close, and place the cask in a cool cellar, and in twenty-four hours it will be fit for use. If intended for bottling let the cask stand undisturbed three days before it be drawn off. For the second brewing, the sediment remaining in the cask may be used instead of yeast. If well-water be used it should be warmed a little.

It ought to be mentioned that very great deceptions are practised, with respect to the essence of spruce brought here for sale from Nova Scotia.

In the sixth volume of the *Museum Rusticum et Commerciale*, a work of considerable merit, we meet with a similar account of making a kind of *Table Beer*, which from its cheapness, and agreeableness, is greatly preferable to that obtained from malt; and which has this farther advantage, that it may be made ready for drinking in three or four days:—"Take fifteen gallons of water, and boil one half of it, or as much as can conveniently be managed; put the part of the water thus boiled, while it is yet of its full heat, to the cold part, contained in a barrel or cask; and then add one gallon of molasses, commonly called treacle, stirring them well together; add a little yeast, if the vessel be new; but, if it has been used for the same purpose, the yeast is

unnecessary. Keep the bung-hole open till the fermentation appear to be abated, and then close it up. The beer will, in a day or two afterwards, be fit to drink.

"It is usual to put tops of the spruce fir into the water which is boiled for making this beer; and it is then called *spruce beer*. But though this is done at sea, when such tops can be obtained, on account of the scurvy; yet it is not necessary, and may very well be omitted, where they are not to be easily procured. Scurvy-grass, or other herbs or drugs, used in making purl, gill-ale, or any other flavoured malt liquor, may be added at discretion. But a little of the outer rind of an orange-peel, infused in the beer itself, and taken out as soon as it has imparted a sufficient degree of bitterness, will both be found grateful, and assist in keeping the beer from turning sour. A very little gentian-root, boiled in the water, either with a little orange-peel, or without, gives also a very cheap, wholesome, and pleasant bitter to this beer."

The philanthropic editor of the "*Reports of the Society for bettering the Condition, and increasing the Comforts of the Poor.*" T. Bernard, Esq. very justly observes, (in a note, vol. i. p. 149.) "that it would be a very desirable thing, that the poor should be able to supply themselves with beer of their own brewing, without being obliged always to recur to the ale-house. I am aware of the disadvantage of brewing in small quantities; but that might be compensated for by great advantages, and by the superior flavour of beer *brewed and drank at home.*—The following recipe is according to the proportions used in the House of Industry, at Shrewsbury: To half a bushel of malt, add four pounds of treacle, and three quarters of a pound of hops; this will make twenty-five gallons of beer; the cost of which (supposing the value of the grain to be only equal to the expence of fuel,) would be two-pence a gallon, where the materials were purchased to the best advantage; and, when bought at the retail shop, about three-pence. I have tried the receipt, and found the beer very good: it was fit for use in a fortnight; but it is not calculated for keeping, particularly in warm weather."

We have been induced to communicate these different methods of preparing a *pure* and wholesome beverage, in order to contribute our mite, however small, towards alleviating the burthens of domestic life. And though we should not succeed in persuading many persons, in the middle ranks of society, to adopt our suggestions, we still may flatter ourselves with the chearing hope, that they will humanely exert their influence on such families as may be benefited by brewing their own liquors at home: instead of carrying, perhaps, one-half of their weekly earnings to the next ale-house, and debarring their helpless children from that necessary assistance, for want of which, they are often doomed to become additional burthens on the parish.

Having pointed out the peculiar qualities of good beer, as well as the most easy and advantageous methods of using a substitute for malt, we shall next consider the most effectual way of clarifying this grateful beverage; and of preventing it from turning sour, or restoring it to its former briskness, when it has, by mismanagement, acquired a tart or insipid taste.

Various schemes have been proposed, and many also adopted in breweries, for *fining* or *clarifying* different beers. But, as the superior brilliancy and transparency of that liquor, depend in a great measure on the quality of the malt and water —which properly belongs to the article "Brewing"—we shall here speak of that process only so far as it relates to the management of beer, after it is fermented.

In Britain, malt liquors are generally fined with ground-ivy, the *Glecoma hederacea*, L; which plant however, will not produce the desired effect, if the beer has been brewed of bad malt, or otherwise mismanaged during the different processes of boiling and fermenting the wort. In such cases, and especially if it has been too long boiled, the liquor may indeed become clear, by throwing into it an additional quantity of ground-ivy; but it will retain an opacity, or turbid appearance, because this useful plant, being at first lighter than the liquid, and swimming on the top, gradually becomes heavier; and though it combines with the impurities of the liquor, and at length sinks to the bottom of the vessel, yet it is incapable of correcting and decomposing those mucilaginous and empyreumatic particles, which partly arise from inferior malt, and are partly extricated by the action of too great and long-continued heat. Hence we shall propose the following simple remedy, which was communicated to us by a continental friend: After the beer is properly fermented, and a few days old, take one gallon out of every barrel, and add two ounces of hartshorn-shavings (or filings, which are still better) to every gallon. Place the liquor over a moderate fire, till it boils, and rises to the top; let the decoction stand for an hour or two; and, when milk-

warm, pour the clear part of it into the barrels, according to the proportion before specified. In this state, the casks must be left undisturbed for twenty-four hours, and then the beer should either be bottled, or drawn off into other vessels. This easy and cheap process, not only has the effect of completely clarifying the beer, but likewise preventing it from turning sour, especially if it be laid up in bottles properly corked, and secured with a cement consisting of nearly equal parts of melted bees-wax, resin, and turpentine.

Beer, should never be forced more than a week before it is tapped, else it becomes stale. Dissolve ½ an oz. of isinglass (fish glue) in as much small beer as will make it of the consistence of thin size, put 1½ pints of this in a barrel, and stir it about.

To give new beer the hard flavour of old beer, add a small quantity of oil of vitriol.

To ropy beer, add a little salt, and roll the cask well

There is considerable damage to be apprehended from the effects of a thunder-storm, by which ale or beer is apt to become turbid and flat, not only at the time when undergoing the critical process of fermentation in the tub, but likewise after it has been barrelled.

In the former case, we are not acquainted with a better method than that of placing (on the approach of a tempest) several vessels filled with lime-water, or where this cannot be immediately procured, only simple water contiguous to the fermenting vat; and, if it be convenient, both fluids in their several vessels should be on a level, or the beer might be somewhat lower than the water; which attracts and absorbs the then prevailing acidity of the atmosphere.

In the latter case, the injurious influence of thunder may be effectually prevented, by laying a solid piece of iron on each cask: this easy expedient we find recorded in the *Gentleman's Magazine*, for January 1753; and the anonymous writer adds, that the fact is accounted for in one of the volumes of the "*Athenian Oracles.*"

In summer, especially in what is called the bean-season, when all malt liquors are liable to become flat, the following remedy is often successfully employed as a preventive: Take a new laid egg, perforate it with small holes, put it in a clean linen bag, together with some laurel-berries, and a little barley; then suspend it in the vessel containing the beer:—instead of the berries and barley, a few leaves of the walnut-tree may be substituted. Others put salt, made of the ashes of barley-straw, into the vessel, and stir it till it be incorporated; or, if the beer is not very sour, a small quantity of such ashes, or calcined chalk, oyster-shells, egg-shells, &c. may be suspended in a similar manner, in order to absorb the acidity of the liquor, and recover its former sweetness.

Sour Beer, however, cannot be easily restored in the manner above stated, without undergoing a new process of fermentation, or impregnating it, for that purpose, with fixed air. But as the latter is an expensive and troublesome method, we shall communicate another of more easy application. Glauber recommended his *sal mirabile* (common Glauber's salt) and saltpetre, to be put into a linen bag, and suspended from the top of the cask, so as to reach the surface of the liquor: thus the beer will not only be preserved and strengthened, but it may also, when flat, or sour, be restored to its former briskness. The experiment may be easily made; but we cannot vouch for its result.

Another, and a better remedy, for recovering tart, or insipid beer, is the following: add to every pint of such beer, from twenty to thirty drops of what is commonly called *oil of tartar* (salt of tartar, or pure pot-ash, reduced to a liquid state, by exposing it to the influence of the air in a cellar, or other damp situation) then mix it in the vessel, and the acidity will be quickly neutralized—Those who live at a distance from apothecaries' shops or wish to prepare this liquid tartar, for occasional use on journies especially in summer, may easily make it, by dissolving two ounces of fine pearl-ashes in eight ounces, or half a pint, of pure water, frequently shaking the bottle, then suffering it to stand for twenty-four hours, and afterwards filtering the solution through a fine cloth. In this state it may be preserved for one year; but beer thus restored ought to be drunk soon after it has recovered its briskness, or at least on the same day: and this small addition of vegetable alkali is, in warm seasons, rather conducive, than detrimental to health.

When beer has acquired a peculiar *taste of the cask*, either from an unclean state of the vessel, or, by long keeping, from the astringency of the oak, it is advisable to suspend in it a handful of wheat tied up in a bag; which generelly removes the disagreeable taste

With respect to the physical properties of malt-liquors, we shall observe, that

they are possessed of various degrees of salubrity, according to the proportion and nature of their ingredients, namely, water, malt, and hops, of which they are composed; and likewise, according to the manner in which they have been brewed. If, for instance, a large proportion of water has been used, the beer will be more proper for quenching thirst, than if it were strongly impregnated with the mealy and spirituous particles of the malt. Hence, strong and sweet beer is the most nourishing and beneficial to thin and emaciated persons; stale and bitter ale, the most intoxicating; and weak, half fermented porter, the most flatulent, and least serviceable to nervous, debilitated, hysteric, or asthmatic constitutions. But, as there is no peculiar test, by which we can ascertain with critical accuracy, when the vinous fermentation is *completed*, and the acetous has *commenced*, every kind of beer must be barrelled, or bottled, before it is *perfectly* fermented, so that the completion of this natural process is effected in the stomach and bowels. Strange as this proposition may appear to some persons, it is so true that the infinite diversity of flavour and briskness obtained from the same mixture, when drawn off into different vessels, or bottles, cannot fail to strike the most superficial observer.

BEET. See Sugar, see also Horticulture.

BERNE-MACHINE, an engine for rooting up trees, invented by P. Sommer, a native of Berne, in Switzerland.

This machine consists of three principal parts: the beam, the ram, and the lever. The beam is composed of two planks of oak, three inches thick, and separated by two transverse pieces of the same wood, of an equal thickness. These planks are perforated with holes to receive iron pins, upon which the lever acts between the two sides of the beam, and is shifted higher as the tree is raised out of its place. The sides are secured at the top and bottom by strong iron hoops. The pins should be an inch and a quarter, and the holes through which they pass, an inch and a half in diameter. When the machine is in action, the bottom of the beam is secured by stakes driven into the earth. The ram, which is made of oak, elm, or some other strong wood, is capped with three strong iron spikes, which take fast hold of the tree. This ram is six or eight inches square; and an incision is made longitudinally through its middle, from the lower end to the first ferule, in order to allow room for the chain to play round the pully, which should be four inches thick, and nine in diameter. The ram is raised by means of the chain, which should be about ten feet long, with links four inches and three quarters in length, and one inch thick. One end of this chain is fastened to the top of the beam, while the other, after having passed through the lower part of the ram, and over the pully, terminates in a ring or link, the two ears of which serve to keep it in a true position between the two planks of the beam. The hook, which should be made of very tough iron, is inserted in this ring; and the handle ought to be two inches thick where it joins to the hook, and gradually lessen in thickness up to the arch, which should be about half an inch in diameter. On each side of the upper pin is a semi-circular notch, which rests alternately on the pins, when the machine is worked. The hole and arch serve to fix a long lever of wood, by means of two iron pins, and thus it is raised or lowered at pleasure, in order to render the working of the machine easy, in whatever part of the beam it may be placed; for, without this contrivance, the extremity of the lever would, when the handle is near the top of the beam, be higher than men standing upon the ground could reach.

This machine is worked in the following manner: it is placed against a tree, and the end of the beam supported by stakes. The iron handle is placed in the opening between the two planks of the beam, and the wooden lever fixed to it, by means of the iron pins. The hook takes hold of the chain, and one of the iron pins is thrust into the outer row of holes, by which means the exterior notch will rest on the pin, which will be the centre of motion; and the end of the lever being pressed downwards, the other notch will be raised, at the same time the chain, and consequently the ram. Afterwards, the other iron pin is to be put into the hole in the inner row, above that which was before the centre of motion, and the end of the lever elevated or pushed upwards, the latter pin on which the notch rests then becoming the centre of motion. By this alternate motion of the lever, and shifting the pins, the chain is drawn upwards over the pulley, and consequently the whole force of the engine exerted against the tree. There is a small wheel joined to the end of the ram opposite the pulley, in order to lessen the friction of that part of the machine.

From this account, the reader will perceive that the machine is a single pulley, compounded with a lever of the first and second order. As the push of the engine is given in an oblique direction, it will ex-

ert a greater or less force against the horizontal roots of the tree, in proportion to the angle formed by the machine with the plane of the horizon; and the angle of 45° is the maximum, or that when the machine will exert its greatest force against the horizontal roots of the tree.

BISCUIT. See BREAD.

BISMUTH, or Tin-glass, one of the semi-metals, of a reddish or light yellow colour, and a lamellated texture: it is moderately hard and brittle, so that it breaks under the hammer, and may even be reduced to powder.

It is very fusible, and soluble in the vitriolic, muriatic, and nitric acids, particularly in the last, and when dissolved in it, is precipitable by a mere dilution with pure water; the precipitate is white; and is commonly called Magistery of Bismuth; it forms the *flake-white*, which when mixed with suet or fat, is used to blacken the hair. Bismuth, dissolved in the acids, forms pellucid sympathetic inks, which become black by exposure to the vapour of alkaline sulphurets.

Most metallic substances, by an union with bismuth, become more fusible; hence it is used in the making of solder, printer's types, pewter, &c.

Bismuth reduced to powder, mixed with the white of eggs, and applied to wood, gives it the appearance of being silvered—when it is gradually dried, and rubbed with a polisher.

This semi-metal is commonly deposited in cobalt-ores; which, when of a high red colour, are called *bismuth bloom* or *flowers of bismuth*. To this mixture may be ascribed the property which bismuth-ore has of making sympathetic ink, similar to that formed by a solution of the regulus of cobalt. See INK.

The very great utility of bismuth in the art of dyeing, and particularly in the manufactory of types, which is yearly increasing in the United States, will cause a considerable consumption of this metal, and render it an important article in commerce.

BIRD-LIME is a viscid matter used for catching birds. There are different ways of preparing this substance, but it is generally made of holly bark, which is boiled ten or twelve hours; and when its green rind is separated, it is covered up in a moist place, to stand for a fortnight. It is afterwards reduced to a tough paste, and washed in a running stream, till no impurities appear. Next, it is suffered to ferment for four or five days during which it must be frequently skimmed. Afterwards it is mixed over the fire, with a third part of nut-oil, or thin grease, and thus rendered fit for use.

The German method of preparing bird-lime, is, by putting about two pounds of lintseed oil into a pot, to simmer upon the fire for some time, after which it is taken off, and lighted with a match. In this state of inflammation, it continues about 2 hours, when half the quantity will be consumed. By dipping from time to time, a stick into the oil, and trying the matter between the fingers, its proper glutinous consistence may be easily ascertained; on which the pot is covered, and the flame extinguished.

Water bird-lime may be prepared as follows: Take a pound of strong and good ordinary bird-lime, wash it thoroughly in spring-water, till it become perfectly soft; next beat it well, that the water may be entirely separated; then dry it, put it into an earthen pipkin, and add to it as much capon's or goose-grease as will render it fluid. In this state of the preparation, add two spoonsful of strong vinegar, one spoonful of oil, and a small quantity of Venice turpentine. Let the whole boil for a few minutes over a moderate fire, stirring it during that process. Then take it off; but previous to its use, warm it, and cover the twigs with it in every direction. This is the best bird-lime for snipes, or such birds as frequent marshy places.

The proper method of using bird-lime is, to cut down the principal branch of a tree, the twigs of which are straight, long and smooth. The willow and birch are the best for this purpose. After the superfluous shoots have been lopped, and the twigs cleaned, they must be uniformly covered with the bird-lime, to within four inches of the bottom; but the main stem should not be touched by this matter. Great care is required in laying it on properly; for, if two thick, it will alarm the birds, and prevent their approach; and, if too small a quantity be applied, it will not hold them when they settle upon it. The branch thus prepared, must be erected in a hedge or among some growing bushes. If employed in summer, it should be placed in a quickset hedge, in groves, bushes, or white-thorn trees, near corn-fields, &c. but in winter, the best spots are near stacks of corn, sheds, or barns. The sportsman ought to stand as near the limed bush as possible, and imitate the notes of birds with a call. When a bird is attracted to the bush, and entangled by the lime, the sportsman should suffer it to remain; as by the fluttering it makes to disengage itself, others will be attracted to the bush, and thus several may be taken together. The hours pro-

per for this sport, are from sun-rise till ten o'clock; and from one, to sun-set. Another method of attracting birds is, by a *stale;* a bat makes a very good stale, but it must be fixed so as to be perceptible at a distance. An owl is still more eligible for this purpose, being followed by the small birds, whenever it appears. If a live owl, or bat, cannot be obtained, the skin of one stuffed will likewise answer; nay, even the image of an owl carved in wood, and painted of the natural colour, will produce the desired effect.

When the German composition is used, care should be taken to seize the bird, when entangled, to prevent it from attempting to free itself by its beak; otherwise it will be destroyed by the deleterious effects of the oil.

The following process appears to be the most easy and effectual method for preserving birds:

After opening the bird, by a longitudinal incision from the breast to the vent, dissecting the fleshy parts from the bones, and removing the entrails, eyes, brains, and tongue, the cavities, and inside of the skin are to be sprinkled with the following powders: Take of corrosive sublimate ¼lb. pulverized nitre ½lb. burnt alum ¼lb. flowers of sulphur ½lb. camphor ¼lb. black pepper, and coarsely ground tobacco, one pound each; mix the ingredients well together, and keep them in a glass vessel closely stopped. First insert the eyes, and stuff the head with cotton or tow; then pass a wire down the throat, through one of the nostrils, and fix it into the breast-bone: wires are likewise to be introduced through the feet, up the legs and thighs, and fastened into the same bone; the body is afterwards stuffed with cotton to its natural size, and the skin sewed over it. In whatever position the bird is placed to dry, the same will afterwards be retained.

Small birds may be preserved in brandy, rum, arrack, or first runnings; but, by these means, the colour of the plumage is liable to be extracted by the spirit. Large sea-fowl have thick strong skins, and such may be skinned; the tail, claws, head and feet, are to be carefully preserved, and the plumage stained as little as possible with blood. The inside of the skin may be stuffed as recommended above.

The following simple composition may also be employed with success, for the same purpose: Common salt one pound, powdered alum, four ounces, ground pepper, two ounces. The bird intended for preservation, should be opened from the lower part of the breast-bone to the tail, with a pair of sharp-pointed scissars, and the whole of the intestines taken out. The cavity is then to be filled with the mixture, and the lacerated part should be properly stitched. The thorax, from the beak to the stomach, must be filled with the same composition, reduced to a fine powder. The head is to be opened near the root of the tongue, with the point of the scissars, and the structure of the brain destroyed, by moving them in a circular direction, and as soon as they are withdrawn, the cavity is likewise to be filled with the mixture. After having been suspended by the legs, for a few days, the bird may be fixed in a frame, in its natural attitude.

BITUMEN. The bitumens form a class of mineral inflammables distinguished by the following properties. They burn with a bright flame and much smoke, leaving behind scarce any earthy residue.

The most convenient arrangement of the bitumens appears to be into the liquid, solid and elastic.

Sp. I. Liquid bitumen, or mineral oil.

Var. 1. Naphtha is either colourless or of a dilute yellowish white colour: it is perfectly fluid and transparent; has an oily lustre and is unctuous to the touch. It has a penetrating but not disagreeable odour, and communicates part of its aroma to water and alcohol, but appears to be insoluble in these fluids, though it combines with ether, the essential oils and resins. Pure ammonia and the caustic fixed alkalies also unite with it into a savonule analogous to Starkey's soap.

The purest European naphtha comes from Monte Ciaro, near Piacenza, in Italy. This hill consists of horizontal beds of argillite, in which pits are sunk till the water comes in, after which the naphtha ouzes out of the sides and floats on the surface of the water, whence it is skimmed off every week. An inferior kind, often passing into petroleum, is procured at Monte Festino, not far from Modena, in the vicinity of which subterranean fires often break out.

But the most copious springs of naphtha with which we are acquainted are at Baku, near Derbend, on the northwest shore of the Caspian sea. The soil is a clayey marl, strongly effervescing with acids, and so thoroughly impregnated with naphtha that when turned up to the depth of a few inches it will take fire on the application of a lighted candle, and continue burning till it is purposely extinguished; the flame is of a pale bluish yellow, and in calm weather rises to the heighth of several feet

The naphtha is procured by sinking pits, into which it percolates, and which are emptied from time to time.

Naphtha is employed as an external application for sprains and rheumatism; the Persians and Russians are said also to use it internally as a cordial. It enters also into the composition of some varnishes.

Var. 2 Petroleum, mineral tar, fossil tar, Barbadoes tar.

The colour of petroleum is reddish or brownish-black; it is more or less translucid; its consistence varies according to its temperature; when warm it is as fluid as common tar, but at 32° of Fahrenheit, it becomes very viscid: it is unctuous and clammy to the touch: it has a strong disagreeable odour and a pungent acid taste.

Petroleum is considerably inflammable, though by no means so readily as naphtha. Alcohol takes up some of its aroma and colouring matter. When distilled with water it comes over more fluid and clearer, approaching to naphtha.

Petroleum combines with the fat and essential oils, with the resins and camphor, and by long digestion dissolves sulphur.

Petroleum appears to be found for the most part in coal strata, or in secondary limestone. There is a spring of this substance at Coalbrookdale, in Shropshire, originating from a stratum of coal: at Pitchford, in the same county, is a coarse-grained sandstone highly impregnated with it. It is also found in various parts of France, Italy, Swisserland, Hungary and Sweden. A few miles from the naphtha wells at Baku, on the Caspian sea, are some very copious springs of petroleum, issuing from hillocks of the same substance hardened by exposure to the air; these springs sometimes take fire, and roll a flaming torrent into the sea, which floating on its surface often covers the water with a sheet of fire to a considerable distance.

No country however produces so large a quantity of petroleum as the Birman empire in Asia: the town of Rainanghong is the centre of a small district in which there are 520 wells of petroleum in full activity. The country in which these are situated consists of a sandy loam resting upon alternate strata of sandstone and indurated clay; under these is a layer of pale blue argillaceous schistus impregnated with petroleum, of considerable thickness resting upon coal. The petroleum begins to flow into the well when it is sunk a few feet into the argillaceous schistus, and when it begins to fail the well is deepened. It is remarkable that no water ever penetrates into these wells. The annual quantity of petroleum produced by the whole district amounts to more than 400,000 hogsheads.

The uses of petroleum where it abounds are very important. It serves the lower classes instead of oil for lamps, and when mixed with earth or ashes it answers the purpose of fuel. A composition of petroleum and resin is found to be an excellent material for covering wood-work and paying the bottoms of ships and boats, as it protects the timber from the attacks of insects or marine worms. Finally, when rectified by distillation, it is applicable to the same purposes as naphtha.

Sp. II. Solid Bitumen, or Mineral Pitch.

Var. 1. Maltha. Cohesive mineral pitch.

The colour of maltha is brownish black; it is opaque, and has little or no lustre; it is tough and soft so as to be impressed by the nail; its fracture is uneven: it has a strong disagreeable odour, acquires a polish when rubbed or cut with a knife, and does not stain the fingers.

Var. 2. Asphalt, Jew's pitch.

The consistence and general appearance of the asphalt is that of pit coal, only the colour is rather grayer: it is very brittle and breaks into small cellular glossy fragments. When put into the fire it boils up for a long time without suffering much diminution, and after a continued heat the surface burns and forms a scoria, underneath which the rest remains in a semifluid state. A gentle heat renders it ductile, and when mixed with grease or common pitch it is used for paying the bottoms of ships, and is supposed to protect them from that pest of the West Indian seas, the teredo or borer.

The uses of asphalt, besides that already mentioned, are as a varnish, and an essential part of the best wax or varnish for the use of engravers. Asphalt is often sophisticated by mixture with common pitch: it may however be readily distinguished from this latter, by having little or no smell, by its not adhering to the fingers, by its superior lustre and minute conchoidal fracture, by its burning without becoming fluid, and by its insolubility in alcohol.

Sp. III. Elastic Bitumen, or Mineral Caoutchouc.

Var. 1. Compact mineral Caoutchouc.

The colour of this substance is yellow-

ish or reddish-brown, hyacinth-red, olive brown and blackish brown. It occurs massive, or mamillary, or stalactitic, or in globular distinct concretions.

It burns readily with a large flame and much smoke: when exposed to a gentle heat it melts, and is converted into petroleum or maltha, or asphalt, according to its previous consistence.

Mineral caoutchouc has hitherto been found only in the Odin mine near Castleton in Derbyshire, in secondary limestone accompanied by calcareous spar, fluor, blende, galena, pyrites, and asphalt.

Var. 2. Suberiform Mineral Caoutchouc. Its colour is that of cream or pale ochre, but by exposure to the air it becomes of a pale reddish brown colour, and its texture is very minutely cellular like cork.

The elastic bitumen appears to be only a peculiar modification of petroleum in its passage to asphalt, and in all probability owes its elasticity to the moisture with which it is combined and to its cellular texture.

All the bitumens appear to be of vegetable origin, but for further remarks on this subject see COAL.

BLACKING, in general, signifies a factitious black; as lamp-black, shoe-black, &c. The common oil-blacking, consists of ivory-black mixed with lintseed oil. The shining blacking is made in various ways, and affords employment to several persons in London, who prepare it for the supply of the shops. The preparation which has experienced the most extensive sale, is probably that of Mr. Bayley. His patent being expired, we shall communicate the particulars of the process. Take one part of the gummy juice that issues, in the months of June, July and August, from the shrub called the *goat's thorn*, four parts of river water; two parts of neat's foot, or some other softning, lubricating oil; two parts of superfine ivory-black; two parts of deep blue, prepared from iron and copper; and four parts of brown sugar-candy. Let the water be evaporated, and, when the composition is of a proper consistence, let it be formed into cakes, of such size that each cake may make a pint of liquid blacking.

Frankfort-blacking is made by a process much more simple. A quantity of the lees of wine is burnt in a well closed vessel, and the residuum reduced to powder, which, when mixed with water, is fit for immediate use; or, if made into cakes, may be preserved for any length of time.

Another preparation for blacking which perhaps is better than either of the foregoing, is thus prepared. Take 1½oz. gum arabic, ½oz. copperass, 2oz. muriatic Acid (spirit of salt) and 4oz. ivory black, moistened with ½ an oz. of oil of vitriol diluted with two or three times its weight of water; mix them well together, and then add 4oz. sugar-candy, 1½oz. sweet oil, and three pints of vinegar; which being shaken, then spread lightly over the boots and rubbed with a stiff brush till dry, will give a brilliant jet black.

A mixture of yellow wax, linseed oil, and ivory black, has been recommended in order to render leather impervious to water; but we think the following preferable for that purpose. Dissolve 1oz. of glue in two pints of water; add 4oz. ivory black, and 2 or 3oz. sugar: mix this with a solution of gum elastic and rosin, prepared with spirit turpentine and linseed oil. Having first wet the leather with a strong decoction of oak bark, apply this composition, which will render the leather water proof, when dry. In the above preparations lampblack will answer, when ivory black cannot be had.

The following composition is also recommended. Tallow half a pound, hogs lard 4oz. turpentine, bees wax, olive oil, 2oz. each; to be melted by a gentle heat, and rubbed on the leather when free from dampness, the night before the boots and shoes are wanted.

BLANCHING, the art of rendering any thing white. The blanching of woollen stuffs is performed with soap, chalk, sulphur, &c. Silk is blanched with soap and sulphur, and wax is rendered white, by exposing it to the action of the sun and dew. See the following article.

BLEACHING is the art of whitening linen cloth, thread, cotton, &c. To attain this end, oils, metallic oxides, earthy impregnations, resins, and other animal, vegetable, or mineral particles, containing any colouring matter, must be discharged from the texture of the substances manufactured.

The process of bleaching is divided into five parts, viz. 1. Steeping and milling; 2. Bucking and boiling; 3. Alternate watering and drying; 4. Souring; and, 5. Rubbing with soap and warm water, starching and blueing. By the first of these methods, the cloth is in a great degree freed from its superficial foulness, and is rendered more pliant and soft. The second process is the most important of the whole. Its object is to loosen and carry off, by means of alkaline leys, that particular substance in cloth, which is the cause of its brown colour. The operation of alternate watering and drying is as fol-

lows: After the cloth has been bucked, it is carried out to the field, and frequently watered, during the first six hours. For, if in the course of that time it be allowed to dry, while strongly impregnated with salts, the latter, by approaching closer together, and being assisted by a degree of heat which increases in proportion to the dryness of the cloth, act with greater force, and destroy its texture. After this time, dry spots are suffered to appear before it receives any water.

By the continual evaporation which takes place on the surface of the cloth, it is evident that this operation is intended to carry off some impurities that remain after the former process of bucking. This is clearly proved from the fact, that the upper side of the cloth, where the evaporation is strongest, attains to a greater degree of whiteness than the reverse side; and the whole likewise turns much lighter on being exposed to the influence of the sun, air, and winds.

Souring—Every person, who possesses the smallest knowledge of chemistry, is aware that alkaline salts may, by various methods, be converted into absorbent earths. One of these is, frequent solution in water, and again evaporating it. A transmutation, therefore, of these salts must be continually going forwards in the cloth, during the alternate waterings and dryings of the former process. The souring process is sooner completed in cold than in warm weather; and it is now experimentally ascertained, that vitriol is preferable to milk sours in bleaching.

The next is *hand rubbing with soap and warm water, rubbing-boards, starching, and blueing*—After the cloth has been sufficiently soured, it is washed in the mill, to deprive it of the acrid particles which adhere to its surface. From the mill, it is taken to be washed by the hand, with soap and warm water, to free it from the oily particles which could not be disengaged by the milling. Soft soap is preferred to hard, for this purpose, as the latter contains a considerable quantity of sea-salt, which is prejudicial to the cloth.

The management of coarse cloth in this operation is very different from that of fine: for the former, instead of being worked by the hands (a method which would be too expensive) is laid upon a table, rubbed over with soap, and then placed between what are called rubbing-boards, which have ridges and grooves from one side to the other, in the form of teeth.

The starching and blueing, which is the last operation, differs so little from the process employed by laundry-women, that it scarcely requires description. But it often happens, that the cloth, when exposed to dry in the open air, after being starched, is wetted by rain, which frustrates the effects intended by the operation: to remedy this inconvenience, many bleachers employ a dry-house, where the linen may be dried in all weathers.

As bleaching is a process still susceptible of improvement, scarcely a year elapses, which does not produce some new discovery in this useful branch of manufacture. We shall, therefore, content ourselves with communicating a few of such hints as may prove advantageous to the practical bleacher; and with which, we presume, there are many persons still unacquainted.

The new method of bleaching with the dephlogisticated or oxygenated muriatic acid, is founded upon the remarkable property which that acid possesses of destroying vegetable colours; and though various attempts have been made to introduce it into this country, the difficulties or disadvantages attending it have prevented its general adoption. This acid was first applied to the purpose of bleaching by M. Berthollet; and the particulars of the process are described at length in a treatise on bleaching, published a few years since, at Edinburgh.

It is to be regretted, that no particular statement of the difference of expence between the old and new methods of bleaching, has yet been laid before the public; but it is probable that the acid drawn from one pound of salt, will whiten four of linen cloth, without any addition. The expence in this case may appear trifling, but when we compute the vitriolic acid which is employed, and that the residuum is almost useless, it will soon be found to be very considerable; and upon the whole, the advantage may be only in the saving of time: but M. Bertholet asserts, that by this method the texture of the cloth is less injured than by that hitherto practised.

The oxy-muriatic acid is also very generally used for bleaching paper. According to M. Chaptal, blotting-paper, when put into it, is bleached without suffering any injury: and old books, and prints, when soiled in such a manner as to be scarcely distinguishable, have been completely restored to their original state. The simple immersion of a print in this acid, is sufficient to produce that desirable effect; but with books some farther precaution is necessary: they should be unsewed, and the adhering leaves carefully separated, that the whole may be equally impregnated.

Mr. Higgins, chemist to the Irish Linen Board, has discovered that the oxy-muriate of lime is, in bleaching, not only cheaper, but in other respects preferable to that of pot-ash. The chemical attraction of the former is somewhat stronger than that of the latter; and, on account of this quality, it does less injury to the cloth. Alternate boilings in solutions of pot-ash, steepings in oxy-muriate of lime, exposure to the action of light, and evaporating water on the green, are found to complete within six weeks, at little more than half the expence, what otherwise cannot be performed in less than double the time.

Notwithstanding this great improvement, Mr. Higgins was anxious to diminish still farther the expence attending the process of bleaching. Convinced that the mixtures of *sulphur* with *soda*, are detergents, or cleansers of the most powerful kind, he was naturally led to conjecture, that lime, which, in other respects, possesses properties nearly similar to those of the fixed alkali, might also resemble them in the detergent effect of their combination with sulphur. He made trial: a sulphuret of lime, composed of four pounds of sulphur added to twenty pounds of lime, and diluted in sixteen gallons of water, formed a solution which answered cold, just as well for the bleaching of linen, as the boiling solution of pot-ash. In consequence of this experiment, he recommends, that linen, after being perfectly cleansed from the weaver's dressing, be immersed *alternately* in solutions of sulphuret of lime, and of oxy-muriate of lime, namely, *six times* in each. By this method, linen may be completely bleached, and with a considerable saving of expence. In Ireland, it is at present almost generally adopted.

Bleaching Linen—In bleaching linen the objects are as follow: to get rid of the sowen or paste used by weavers: to destroy the colouring matter of the cloth; to give additional whiteness when this is destroyed; to give apparent fineness to the cloth.

Into a tub sunk in the ground, put any number of pieces from 50 to 100 immersed in water. Let them stay therein for two or three days, until there is an appearance of fermentation. Take them out and dash them well in the dash-wheel, and lay them down on the grass till dry. Into a cuir or round tub about four feet six inches deep, capable of holding 220 pieces of common Irish linen, put in that quantity. The upper pieces should be covered by pieces twisted and placed very close, so that the steam may be somewhat confined; near the bottom of this cuir is a hole, stopped occasionally with a plug through which the liquor is let out into an iron pan just below. Under this pan is a fire, with its proper flue. Put into this iron pan 70lb. of good pot-ash. Fill the pan with water and make a fire under it. The pan should hold just enough to let the liquor cover the cloth when the cuir is full and the plug in.

By the side of the pan stands a man with a tin vessel, holding about a gallon, fixed at the end of a wooden handle; with which he continually lades out the liquor in the pan to the cloth, distributing it evenly, beginning with it cold, and continuing as it boils from morning to night, occasionally filling up the pan to prevent the alkaline solution being too strong. This operation, which should continue nine hours, is called *bouking*.* The cloth is

* A very ingenious and simple method of effecting this has been suggested by M. Chaptal, and the experiments which have been made appear to confirm the value of the proposed alteration. M. Chaptal's method of bucking, consists in exposing the cloth when impregnated with caustic alkali to the action of steam raised to a somewhat higher temperature than that of boiling water. For this purpose a square or rectangular shallow boiler is firmly fixed in masonry, and a vault of stone-work lined with lead is raised over it; at one end is a door sufficient to admit a man, made to fit very closely, and capable by the action of screws of being rendered steam-tight. Within the vault are fixed reels, by means of which either cloth or yarn can be wound off one on to the other, by a somewhat circuitous route, during which it is made to pass through the liquor in the boiler and is also exposed to the action of the steam. The cloth or yarn being previously steeped for a few hours in an alkaline ley is wound upon one of the reels, and a quantity of ley is also poured into the boiler; the door of the vault is then secured and the fire under the boiler is lighted. This being done, the cloth is slowly transferred from one reel to the other, and afterwards returned to the former one, by means of a winch worked by hand or machinery on the outside of the vault. This being performed in a dense atmosphere of very hot steam, and the cloth in one part of its progress passing through the liquor in the boiler, the colouring matter of the cloth is much more speedily extracted than by the common process of bucking. Hence not only time is saved but the beating to which the goods are subjected in the wash-wheel, and by which their strength is in some degree injured, may be considerably lessened.

thus left all night, taken out in the morning, well dashed and laid down on the grass for about a week, being turned every day or two. It must undergo this operation of *bouking* a second time with from 50 to 60lb. of pot-ash, and being well dashed, is laid down as before. It is now soured in vitriolic acid and water in tubs sunk in the ground: the mixture should be the strength of *strong* vinegar or a little more. In this souring they should continue two days and nights at least: then dashed well; layed down for a week and turned as before. The pieces should then be *bouked* with 30lb. of pearl ash, and ten pounds of soap to a cuir; dashed, laid down for three or four days: then soured, dashed, laid down for three or four days, turned, &c. as before.

Bouk again with 25lb. of good pearl ash to a cuir. Dash, lay down for two or three days, and then sour if you please in the oxygenated muriatic acid, made in the manner directed in the article, Muriatic Acid. If you do not use the oxygeneted acid, sour again in common vitriolic acid for six or eight hours, and wash it extremely well. *Indeed, perfect dashing continued to a certainty till all the acid is washed out, is indispensible:* otherwise the pieces would rot on the ground when dry.

Less than a month is not sufficient to get a piece of linen cloth perfectly white, though half that time will do for callicoes in England—But in America the superior heat of the sun will save at least one fourth of the time in laying down the pieces. After this process, the cloth is put under the operation of the rubbing boards, which certainly injure the texture, as appears by the knap in the teeth, although the more soap is used the less injury is done. But it is a part of the manufacture which may be omitted where the cloth is required to gain credit by the strength of its texture.

After the rubbing boards the cloth is gradually wound round cylinders of wood and beetled—The beetles are stampers lifted up by a cog-wheel, and let fall on the cloth, as it is slowly taken up round a turning cylinder. This is also a part of the operation by which the thread is flattened, and the cloth made to look finer at the expence of the texture.

It is then run through a very thin solution of fine starch, and blued with smalt. Then run through two cylinders to give it evenness and gloss, and made up for market.

The manner of bleaching fine linen cloths, with the method of preparing them as practised in Picardy, (*France.*)—After the linens are taken from the loom, they are put to soak in clear water for a whole day: when they have been well washed and cleansed, they are taken out and thrown into a bucking tub filled with cold lye made of wood ashes and water, which has been used in former processes. When they are taken out of that lye, they are washed again in clear water and spread in a meadow, where they are occasionally watered with clear water out of small canals made for that purpose in the ground. They water them with scoops or hollow and narrow wooden peels, with a long handle. After lying a certain time on the ground they pass them through a fresh lye poured on hot: this lye is of different strength according to the quality of the linen. Being taken out of this second lye, they are worked in clear water, and laid again in the meadow; all which several operations are repeated until the linen has acquired the desired degree of whiteness. They are afterwards put into a weak lye, to restore the softness which the preceding strong lyes had deprived them of; and after this they wash them in clear water.

They next rub them with black soap, which finishes whitening the selvages, which would never become perfectly white without the help of soap.

Then they wash them well, to take off all the soap, and put them to soak in sour cows' milk, the cream being first taken off. This perfects their bleaching, gives them all their softness, and makes them cast a little nap, Being taken out of the milk, they are washed again in clear water for the last time. When they have undergone all these operations, they give them the first blue; that is to say, they dip them into water in which a little starch has been dissolved, together with smalt, or Dutch lapis, of which the fattest and palest is the best, for the linens must not have too blue a cast.

The linens being thus bleached, after the manner we have related, the bleachers or whiteners deliver them into the hands of the merchants to whom they belong, who cause them to be properly made up.

These preparations differ according to the qualities of the linens: for there are some which ought to preserve all their strength; and others the strength of which must be diminished, in order to render them clearer.

Lawns or cambrics are prepared with starch and pale blue, or smalt diluted with clear water. They add some other drugs, the quantity and quality of which depend on the workmen's knowledge and capacity.

Being thus prepared, they are fastened with ropes to poles fixed in the ground at some distance from each other. When they are three quarters or half dry, they take them from the poles, and beat them on marble blocks, with very smooth wooden mallets, which is done to beat down the grain, and give them a more beautiful appearance.

After this, they fold them into small squares, and press them. When they come out of the press, the dealers in France put their numbers upon them, which are written or stamped upon small pieces of parchment, and tied to the selvage of the piece with silk of different colours, according to the merchant's fancy, who calls that silk his livery; each merchant having his particular colour, which he never changes.

After this, they wrap up the pieces very neatly in brown paper of Rouen, well beaten, tied with small packthread, which they commonly get from Holland. The linens are then in a proper condition to be sold, packed up, and sent to the places where they are disposed of.

All the clear linens of Picardy, such as plain, striped, or spotted lawns, are prepared after the same manner as those before mentioned; except that these are beaten, but those of Picardy are not.

It must be observed that the fairer the weather is, the easier are the linens bleached. In fair weather they may be bleached in a month's time; but, in foul weather, six weeks, or more, are hardly sufficient to complete the operation.

It must also be observed, that all the linens, of whatever kind they are, which are bleached in Holland, Flanders, and Picardy, are dipped in cows' milk after the cream is taken off; it being certain, that it is this liquor which gives them that delicate whiteness so much admired in the linens which come from those different countries.

It is customary with the merchants who send their linens to the bleaching-grounds of Flanders and Picardy, to mark them at each end with one or more letters of their names (which marks are made with thread of Epinay, worked with the needle) and to fasten at the places where these marks are put, some small twists, made also of the same thread of Epinay; which twists have a certain number of knots, at some distance from each other; each knot having its particular value, according as every merchant thinks proper. The marks are put, in order to know to whom each piece belongs; and the twists, to remember the prices.

The method of bleaching common linens, as it is practised in Anjou.—Immediately after the pieces are taken from the loom, they are carried to the whitner, or bleacher, who puts them directly into wooden troughs, full of cold clear water; where, with wooden mallets, which are moved by a water-mill, they are so well agitated and beaten, that they are insensibly cleared from all their impurities.

Being taken out of the mill, they are spread on a meadow, where the dew which they receive during a week begins to bleach them.

Then they are put into a kind of wooden tubs, when they throw over them a common lye, quite hot.

The linens having thus gone through the lye, they take them out of the tub, to clean them again in the mill; then they spread them a second time in the meadow, where they leave them a week, after which they give them a second lye: all these several operations are repeated until the linens have acquired a perfect degree of whiteness. Then they fold them up, after a manner proper to each sort, and to the places for which they are designed.

Bleaching of Cotton.—The process is exactly the same as for linen, only requiring less time and labour, viz.—

1. Steep the grey cloth for two or three days, then wash.

2. Bouk with 70lb. of pot ash to 230 pieces of callico of 28¼ yards each, or muslinets, velverets, &c. in proportion, that is to a cuir, full, which will hold 230 callicoes in the grey. A cuir that will hold 230 callicoes will not hold quite so many of Irish linen of equal length.

3. Lay the goods down on the grass three days, turning them each day.

4. Bouk with 50lb. of good pearl ash, and about 5lb. of soap. Dash, lay down for three days as before.

5. Sour in vitriolic acid and water, the strength of *strong* vinegar for two days.

6. Dash well, lay down for three days as before.

7. Bouk with 30lb. of pearl ash, dash and lay down for three days.

8. Bleach with oxygenated muriatic acid. Dash well, lay down for a day; dash again and make up the calicoes."

A new method of bleaching cotton thread and hosiery has been adopted in Swabia. The operation is performed in two days, and does not require extensive premises. An alkaline caustic ley is prepared, by taking two measures of quick lime, and covering them with ten measures of good ashes; the heap is then to be sprinkled with water, and when the lime is slacked, and the mass cooled, it

is fit for making the ley by the addition of cold soft water. The skeins of cotton being untwisted and tied in parcels, are to be immersed in the ley, in which they are to be left six hours, and to be occasionally turned; they are then to be washed in a river, and afterwards boiled twelve hours in a bath of the same kind of ley, in which for every sixty-six pounds of cotton thread, six pounds of soap have been dissolved; they are then to be boiled the same length of time in a solution of soap and water only, according to the former proportion; after which, they are again to be washed in the river, and hung up in the air, or laid on the grass, to dry as quickly as possible. The process for the hosiery is similar. The boiler must be made of copper, and always well cleaned after it has been used.

The successful experiments made by Berthollet in bleaching vegetable goods, by means of the *oxymuriatic* acid, seem to have brought this art nearly to a state of perfection. But this method is not in every instance, equally economical. It requires to be performed by very skilful operators, in order that the goods may not be affected by a ley too corrosive, or applied at an improper time; independent of which consideration, it is desirable that every process should be completely disclosed, in order that the artist may choose such means as may best suit his pursuit. This consideration has induced the publication of the following account of Chaptal's simple and economical mode of bleaching cotton thread.

At the height of about 17 inches above the grate of a common furnace, a copper boiler is placed, of a round form, 19 in depth, and 52.49 inches in diameter. The projecting rim of the boiler, which is about 7 inches, rests upon the brick work of the furnace. The remainder of the kiln is made of free stone, and forms an oval boiler or digester, about 78 inches in height, and its width, when measured at the centre, 52 inches.—The upper part of this vessel has a round orifice, about 19 inches in diameter, which is closed when necessary, by a large moveable stone, or by a copper lid adapted for the purpose. On the flank of the copper vessel, which forms the bottom of this digester, a grating is laid, which consists of bars of wood placed near enough to prevent the cotton that is put on them from falling through, and sufficiently strong to support the weight of 1780 pounds. When this structure is completed, the cotton thread, having been previously divided into parcels or hanks, is slightly impregnated with a solution of soda, rendered caustic by lime. This operation is performed in a trough of wood or stone, and as soon as the cotton is sufficiently impregnated with the alkaline liquor, it is conveyed to the digester, and piled upon the wooden-grate. In this situation, the exuding liquor runs through the bars into the copper boiler, where it forms a stratum of fluid, and allows the whole mass to be heated, without danger of burning either the cotton or the metal. The alkaline ley is composed of the best potash, one tenth part of the weight of the cotton in quantity.

After the cotton is properly disposed in the boiler, the cover is put on, and very little issue left for the disengaged vapours, in order that they may acquire a greater degree of heat, and act more powerfully on the cotton. When the digester is charged, the fire is lighted in the furnace, and the ley submitted to a gentle ebullition from 20 to 36 hours. It is then suffered to cool, the cover taken off, the cotton carefully washed and exposed on the bleaching ground for 2 or 3 days, by spreading it on frames during the day, and on the grass at night. Thus the cotton acquires a beautiful degree of whiteness; and if some portions should accidentally remain unbleached, which may happen from its not having been equally and completely impregnated with the ley, those portions must be replaced and subjected to a second operation, or left in the bleach-field for some days longer.

The oxygenated muriatic acid was discovered by Scheele; its application to bleaching was first suggested by Berthollet and Chaptal in France, and used at Glasgow, by Mr. Watt, and in Manchester in the year 1791 in a large way, first by Baker and Co. whose process has never yet been made public, and is that now about to be detailed.

The method of making this acid for bleaching, yet used in Manchester and elsewhere, is by adding to 3 parts, by weight, of manganese, 8 parts of common salt and 6 parts of oil of vitriol, and 12 of water—These are distilled together, and the products received in barrels of water, arranged in the manner of Wolfe's apparatus, by tubes communicating from the retort to the first barrel, and from the first to a second. Sometimes the water is only impregnated with the acid, sometimes it is made to saturate lime or pearl ash. This process cannot be used with economy: the trouble and expence of retorts, and the attendance on the fire render it complicated so as ultimately to bring it into disuse. It has not yet, and never will answer for goods in general.

Where particular patterns are suddenly wanted for the market it may pay.

The writer of this article attended for three years continually to the bleaching of cotton goods of various kinds, to the amount of 800 pieces of callico per week, on the average of the year, by the following process. The goods underwent three boukings, as described before in this article, and two acid baths. The third was the oxygenated muriatic acid, made as follows. In a building of one room on a bank and another over it, were placed on substantial frames or tressels, five wooden cylindrical machines four feet diameter by five feet long, the staves two and an half inches thick and well dove-tailed. Into each of these, twice a day, through a funnel inserted in a two inch augur hole and let through the floor of the upper room, was poured 75lb. of salt and 25lb. of red lead. To this was added 40lb. of oil of vitriol, weighing 29½ oz. to the wine pint.

The machine was then filled with water, the augur hole stopt with a plug and rag, and then turned round 20 or 30 times, and in 15 minutes the acid was made.—The vitriolic acid acts on the salt, and the marine acid thus produced on the red lead, which in a few minutes is deprived of its oxygen. The handle of each machine was fixed on the centre of one of the ends with two cross-bars [X]—The acid when made was let off on the pieces placed in wooden vessels in a room adjoining and below. It frequently occasioned a spitting of blood among the workmen who took out the pieces, but was never attended with any further deleterious effects: laudanum relieved the short phthisicky cough. One of these vessels full was allowed to 60 muslinets. No lead remained in the liquor.

This process may be imitated in a small way, by pouring into a *strong* vial, with a glass stopper, about an ounce of spirits of salt on a tea-spoonful of red-lead; stop the vial; heat is generated, the lead turns white and a very strong oxygenated acid is produced in a minute's time. But this acid will contain a little lead, while the acid made with vitriol and salt does not. This acid has lately been recommended by Guyton Morveau, as an effectual destroyer of putrid exhalation.

We shall abstract the patent lately granted to Mr. Turnbull, for an improvement in the common process of bleaching cotton, or linen pieces: Take any kind of earth which is easily mixable with water, such as clay, marl, or Fuller's earth, or if that cannot be had, any kind of soft mud or the like, which is put into a boiler to evaporate the moisture; dried, again mixed with water, and passed through fine sieves. This powder is then mixed with quick-lime, which is slacked in the earthy mass, and forms the materials for the several *boukings* which the cloth is to undergo. The pieces are to be worked in the bouking tubs for a number of times, alternating this operation with rinsing and souring, as is usual in the long established method, and afterwards exposing them to the air, on the bleaching ground. The only difference in the process here employed, is the admixture of earthy mud, or clay, to the lime, so that the corrosive power of the latter is diminished, and may consequently be used more freely. In the last boukings, potash is also added to the earthy mixture. Hence the patentee's method unites that of fulling with soap, or washing with alkaline lye; and it is very probable, that by such a combination not only time, but also expence may be saved, as alkali is the most valuable article used in the process.

In January, 1798, a patent was granted to Mr. C. Tennant, for his method of using calcareous earths, especially those known under the names of barytes and strontites as substitutes for alkalies, in neutralizing the muriatic acid gas employed in bleaching, &c. and the patentee directs such calcareous earths to be calcined, pulverized, and sifted; after which a certain portion of quick-lime, according to the degree of strength required, must be thrown into the vessel usually employed in the preparation of the bleaching liquor, for the purpose of retaining the oxygenated muriatic gas. When the ingredients generally employed, namely, manganese and spirit of salt, have been introduced into the retort, and the gas begins to rise, the liquor contained in the receiver ought to be constantly agitated, so that the fine particles of the lime may be diffused throughout the whole of such fluid; for the success of the process depends chiefly on this circumstance. As soon as the manganese, or other material, ceases to yield the oxygenated muriatic acid gas, the whole should be suffered to remain at rest, for two or three hours; after which the clear liquor must be decanted for use; Mr. T. farther observes, that if these calcareous earths be *mechanically* suspended in water, or other aqueous fluid, they will unite with such gas, and form a compound that may be advantageously employed in bleaching.

The liquor, thus prepared, is not only

a considerable saving in the article of ashes, but also the time usually required for bleaching is remarkably shortened.

It will be observed, that the proportions of the ingredients are varied, and must in some measure depend on the goodness of the articles. Mr. Rupp of Manchester recommends manganese 3 parts more or less according to its quality, common salt 8, oil of vitriol 6, water 12. Mr. Tennant of Glasgow, equal weights of manganese, salt, and sulphuric acid, with a quantity of water equal to the acid in measure. In Ireland, the common proportions are said to be manganese 6 parts, common salt 6, sulphuric acid 5, water 5. In France and Germany we understand they vary little from the following: manganese 20 parts, common salt 64, sulphuric acid 44, water 54. It must be observed, however, that, as the efficacy of the acid depends upon the oxigen imparted to it by the manganese, a deficiency of this article must render it less efficacious. The process of distillation may be performed in a large leaden alembic, supported by an iron trevet, in an iron boiler.

But instead of this apparatus, which is peculiarly adapted for making a solution of hyperoxigenated muriat of lime, some, as before noticed, employ a series of large barrels disposed in the manner of a Woulfe's apparatus, disengaging the oxigenated muriatic acid gas in one or more tubulated retorts, either of lead or stone, properly arranged for the purpose; or receive the gas thus disengaged into the vessels in which the goods are to be bleached. But whatever mode be adopted, every possible precaution should be employed, to prevent the escape of the gas into the air, to the injury of the workmen.

If the bleaching liquor be not made in the vessel in which it is to be used, it is proper to draw off the liquor from the cask as soon as it is prepared, because it acts upon the wood, and not only becomes by this means weaker, but likewise hastens the destruction of the cask: but when it is conveyed into a vessel in which cloths are properly placed, these speedily weaken it to such a degree, that it does not perceptibly act upon the wood.

The cloths are to be prepared by leaving them twenty-four hours in water, or still better in the old lixivium, to extract the dressing; after which they must be once or twice well washed in alkaline lixiviums, because all that part which can be extracted by the lixiviums would have neutralized a portion of the liquor, which requires to be carefully used. After this the cloth must be carefully washed, and disposed upon sticks, in such a manner, that it may be impregnated with the liquor poured on it, without any part being compressed. The framing of the sticks, as well as the cask and vesse intended to contain the cloths, ought to be constructed without iron; because this metal becomes calcined by the oxigenated muriatic acid, and would produce iron-moulds, not to be taken out but by means of oxalic, or dilute sulphuric acid.

The first immersion must be longer than the following ones; it may last three hours: after which, the cloth is to be taken out, lixiviated anew, and then put into a shallow vessel, in order that new liquor may be poured on it. It is sufficient, that this immersion, and the following, should continue for the space of half an hour. The cloth is taken out, and cleared of the liquor by pressure; then lixiviated, and subjected to new immersions. The same liquor may be used until it is exhausted: and when it is found to be much weakened, a proportion of the liquor which has not been used may be added.

When the cloth appears white, excepting at the selvages, and a few threads darker than the rest, it must be impregnated with black soap, and strongly rubbed; after which it is to be lixiviated for the last time, and immersed once more in the liquor.

The number of lixiviations and immersions which are necessary cannot be determined, because it varies according to the nature of the cloth: the limits of this number, however, are between four and eight, for linen and hempen cloths. M. Berthollet expresses his inability to point out the best method of making the alkaline lixiviums; this useful art being still a matter of mere practice, and variously performed in different places. It appeared advantageous to him, to render the alkali caustic by mixing one third of lime; but in this case care must be taken that the lixivium be strained through a cloth, in order that the calcareous earth may not mix itself with the linen, as its particles might corrode or wear it by their hardness. By this management the lixivium being rendered more active, it does not require so large a quantity of alkali; and nevertheless, if the quantity of alkali be not too considerable, it produces no damage to the cloth, notwithstanding the contrary prejudice, which is very general. He has likewise remarked, that it was of no advantage, and even prejudicial, that the lixiviations should be of long duration; but it is necessary that the fluid be very hot, and of considerable strength, otherwise the cloths bleached by the oxigenated

muriatic acid would become coloured and ruddy when submitted to new lixiviations. Cottons are much more easily and speedily bleached than linens: two lixiviums, or at most three, with the same number of immersions in the liquid, are sufficient; and as they are so much the more readily bleached, it is advantageous, when linen, hemp, and cotton are to be bleached, to reserve the liquors for the latter, which have been already weakened by exerting their action on the former. Such liquors as are so exhausted as scarcely to act upon hemp or linen will do very well for cotton.

After the last immersion in the liquor, the cloth must be plunged into sour milk, or water acidulated with sulphuric acid. The true proportion is not well ascertained; but Berthollet thinks, from his experiments, that one part of the acid by weight, with fifty parts of water, may be employed successfully and without danger. The cloths are to be kept about half an hour in this fluid, warmed; after which, they must be strongly pressed, or wrung, and immediately plunged into common water: for, if they were suffered to dry by evaporation, the sulphuric acid, becoming concentrated, would attack them. When the cloths are well washed, they must be passed through a weak alkaline lixivium, and rinsed a second time; after which nothing more is necessary than to dry and prepare them in the usual manner.

It is an obvious precaution, that this acid water be not too strong, as it would of course injure the texture of the stuffs: and soap must not be used after it, as a lixivium, for this would render them yellow.

To avoid the inconveniences arising from the escape of the gas, which we have mentioned above, potash was added to the water in the receivers. But this was found to add considerably to the expense, and diminish the strength of the liquor. Mr. Tennant of Glasgow employed a cheaper material, quicklime, added to the water in the receiver, and kept in continual agitation. As lime is very little soluble in water, what is not saturated with the acid will subside to the bottom, if the liquor be left to stand after all the gas is come over. If thirty pounds each of manganese, salt, and sulphuric acid, be used, Mr. Tennant puts sixty pounds of finely powdered quicklime into his receiver, which is capable of containing a hundred and forty wine gallons of water. He likewise previously dissolves thirty pounds of common salt in the water, but this does not appear to us to be necessary. Indeed, by increasing the specific gravity of the water the lime does not subside in it so quickly, and probably a small portion of hyperoximuriat of potash is formed.

In bleaching with the oxigenated muriatic acid, it is of consequence to ascertain its relative strength, in order that the experiments may be at all times equally successful. Mr. de Croisille made use of a solution of indigo in the sulphuric acid; for which purpose he took one part of finely pulverized indigo, with eight parts of concentrated sulphuric acid. This mixture is kept in a matrass for several hours on the water bath; and, when the solution is complete, it is diluted with a thousand parts of water. In order to ascertain the force of the oxigenated muriatic acid, one measure of this solution is put into a graduated tube of glass, and the liquor or impregnated water is added, until the colour of the indigo is completely destroyed. In this way it is ascertained, by means of the graduations, how many measures of any liquor, the goodness of which has been found by direct experiments upon linen or cotton, are necessary to destroy the colour of one measure of the solution of indigo; and this number will serve to ascertain the respective force of all the liquors, which are required to be compared together. Mr. Watt makes use of a decoction of cochineal for the same purpose.

All the colours of calicoes or printed goods may be discharged by the oxigenated muriatic acid, or hyperoxigenised muriat of potash. The blues, yellows, and blacks indeed require a previous bath of water acidulated with sulphuric acid; and according to their shade two or three immersions in the oxigenated muriatic acid, alternately with this bath, may be necessary. The Adrianople reds will always retain a ruddy tinge, on account of the oily matter that enters into their preparation, let them be immersed ever so often. All other colours require only a single immersion, without any previous lixiviation.

Silk too, and woollen dyed of certain colours, may thus be rendered white; but they must be exposed to the action of sulphurous acid gas, to remove the yellow colour left by the oxigenated muriatic acid.

The rags or other materials for making paper may be bleached in a similar manner: but it is best to reduce them first to the state of pulp, as then the acid acts more uniformly upon the whole substance.

For bleaching old printed paper, to be

worked up again, Pajot Descharmes gives the following directions: Boil your printed paper for an instant in a solution of caustic soda. That from kelp may be used. Steep it in soapsuds, and then wash it; after which it may be reduced to pulp. The soap may be omitted without much inconvenience. For old written papers to be worked up again: steep it in water acidulated with sulphuric acid, and then wash it well before it is taken to the mill. If the water be heated it will be more effectual. To bleach printed paper, without destroying its texture. Steep the leaves in a caustic solution of soda, either hot or cold, and then in a solution of soap. Arrange them alternately between cloths, as papermakers do thin sheets of paper when delivered from the form, and subject them to the press. If one operation do not render them sufficiently white, it may be repeated as often as necessary. To bleach old written paper, without destroying its texture: steep the paper in water acidulated with sulphuric acid, either hot or cold; and then in a solution of oxigenated muriatic acid; after which immerge it in water, that none of the acid may remain behind. This paper, when pressed and dried, will be fit for use as before.

With a view to bleach wax, it is cut in small pieces, melted and poured into cold water, where it granulates. In this state it is exposed to the sun and air, melted and granulated repeatedly, then submitted to the influence of the sun, air, and dew in the interval between each liquification. When the wax is perfectly blanched, it is dissolved for the last time and cast into flat moulds, in which it is always exposed to the air, for one or two days, in order to render it more transparent.

The *animal* fibres that are subjected to the bleaching process are silk and wool. These cannot be treated in the same manner as vegetable substances: a strong alkaline ley will dissolve them, and oxymuriatic acid will both weaken them and turn them yellow.

The method of bleaching Silk.—The silk, being still raw, is put into a bag of thin linen, and thrown into a vessel of boiling river water, in which has been dissolved good Genoa or Toulon soap.

After the silk has boiled two or three hours in that water, the bag being frequently turned, it is taken out to be beaten, and is then washed in cold water. When it has been thus thoroughly washed and beaten, they wring it slightly, and put it for the second time into the boiling vessel, filled with cold water, mixed with soap and a little indigo; which gives it that blueish cast commonly observed in white silk.

When the silk is taken out of this second water, they wring it hard with a wooden peg, to press out all the water and soap; after which they shake it to untwist it, and separate the threads. Then they suspend it in a kind of stove, constructed for that purpose, where they burn sulphur; the vapour of which gives the last degree of whiteness to the silk.

The method of bleaching Woollen Stuffs.—There are three ways of doing this. The first is with water and soap; the second with the vapour of sulphur; and the third with chalk, indigo, and the vapour of sulphur.

Bleaching with Soap and Water.—After the stuffs are taken out of the fuller's mill, they are put into soap and water, a little warm, in which they are again worked by the strength of the arms over a wooden bench: this finishes giving them the whitening, which the fuller's mill had only begun. When they have been sufficiently worked with the hands, they are washed in clear water and put to dry.

This method of bleaching woollen stuffs is called the Natural Method.

Bleaching with Sulphur.—They begin with washing and cleaning the stuffs thoroughly in river water; then they put them to dry upon poles or perches. When they are half dry, they stretch them out in a very close stove, in which they burn sulphur; the vapour of which diffusing itself, adheres by degrees to the whole stuff, and gives it a fine whitening.

Bleaching with Chalk, Indigo, and Sulphur.—When the stuffs have been well washed in clear water, they throw them into a bucket of cold water, containing chalk and a little indigo, wherein the stuffs are well stirred and agitated: then they take them out, and wash them again in clear water; after which they hang them on poles: when they are half dry, they put them into a stove to receive the vapour of sulphur, which finishes their perfect whitening.

This bleaching is not the best, though very agreeable to the eye.

It must be observed that, when woollen stuffs have once imbibed the vapour of sulphur, it is a difficult matter to make them take a good colour in dyeing, unless it be a black or blue.

The colour of manufactured wool resides partly in its own oil, and partly in

the greasy and mucilaginous applications which it receives in being prepared for the loom. Both the one and the other are also easily got rid of by the action of fuller's earth and soap in the process of fulling. Fuller's earth is a very fine grained absorbent earth, which by itself is capable of mixing rather than combining with vegetable or animal oils, and rendering them miscible with water; its action is found however to be increased by the addition of soap; and woollen cloth being beat in a fulling mill with hot water, and a proper mixture of earth and soap, or of soap alone, and afterwards well washed and dried in the air, receives all the bleaching which it requires or is indeed capable of. It is then of a white colour, somewhat verging towards yellow; this last tinge may be made to disappear by the addition of a very small quantity of stone blue in the water in which the cloth is last washed, or by exposing it to the fumes of burning sulphur; by this latter method however it acquires a certain harshness of feel and is apt to turn very yellow when washed with soap.

BOILERS. Many ingenious vessels and utensils have, at different periods, been invented, with a view to facilitate the process of boiling, and save the consumption of fuel. In the latter respect, count Rumford stands at the head of those experimental inquirers, who have directed their labours to the benefit of society; yet we must confess that there is still great room for improvement. One of the latest inventions in this department of domestic economy is that of Mr. Thomas Rowntree, engine-maker, of Great Surry-street, Blackfriars-road, London, and the following is a literal abstract of the inventor's description. "For heating of coppers, boilers, furnaces, ovens, and stoves, my fire-place is much smaller than heretofore made use of for the same sized copper, boiler, furnace, oven, or stove. Instead of placing my fire-place, according to the common practice, immediately under the boiler, or other vessel, I place it at the front, side or end, as I see most convenient, in such a manner as to oblige the flame to rise in the front, side or end, and pass all round the vessel, &c. while at the same time it strikes the bottom of the vessel, &c. without suffering the flame to pass off in a flue, or flues, as it usually does in the common way, and by that means sending the heat into the flues, instead of its being used where it ought to be, namely, on the vessels, &c. this, my method effectually prevents; for, by means of a small perpendicular, or other opening, into a box or trap, which I call a reservoir, and which I place horizontally, or diagonally, as the situation may require, and is made of iron, brick, stone, or any other material capable of bearing heat, where a valve is placed riding on centres or otherwise, and standing in a diagonal or other direction, as is found most convenient; the flame is returned or impeded in its progress to the chimney, aud made to descend below the bottom of the vessel, and pass out at the bottom, top, or side of said box, trap, or reservoir, into the common chimney. This reservoir is placed between the vessel, &c. and the chimney. To the opening, which admits the flame into the reservoir, are affixed, when necessary, sliders, registers, or stops, which serve to increase or diminish the heat. The valve in the reservoir is for the same purpose in another degree, which more immediately appertains to increasing or diminishing the draught, which it does by moving the said valve into different positions, as the speed of the operation may require."

It would be needless to state the particulars of the evidence relative to the effect produced by the new invented furnaces, in heating boilers, &c. as well as the great saving of fuel, which was proved to be more than *one-third*, and in some cases nearly *one-half*, of what is usually consumed in furnaces constructed on the old plan. Hence we shall communicate only the substance of Mr. Hindmarsh's evidence, which greatly tends to illustrate the principles of the invention. This, he conceives, principally consists in the three following circumstances:

1. In the peculiar mode of constructing the furnace, or setting the boiler, and of placing the fire, not immediately under, but a little in front, or at one side of it, whereby the flame and hot air can get access to every part of the vessel, and not only strike with force against its bottom, but also with equal effect reverberate against, and violently embrace its sides, and whole external surface; unlike every former contrivance, the most perfect of which could only cause the flame and hot air to act partially upon the bottom and sides of the vessel.

2. In the elevated situation, and smallness of the aperture leading from the furnace towards the chimney; whereby the flame and hot air are impeded in their progress to the atmosphere, and compelled to tarry in the cavity of the furnace, and occupy every part thereof much longer than they otherwise would do. This effect in stopping, checking, and as it were arresting the flame and hot air, in

their attempt to escape into the atmosphere, Mr. Hindmarsh considered as not only new, but singularly beneficial; for, by this means, the flame and hot air are detained in the very place where their presence is most wanted, and constrained to give forth their energies with an *impetus* against the bottom and sides of the vessel to be heated: whereas, in none of the furnaces heretofore erected, was any effectual stop interposed between the fire and the chimney, to cause the flame and hot air to dwell under and round the sides of the vessel; but they passed rapidly off into the atmosphere, either by a direct communication through the chimney, or indirectly, but almost as speedily, by flues; or else by a drain (as it is called,) the aperture of which is equal in dimensions to that of the chimney itself.

3. In an open space between the furnace and chimney, called by the Patentee a box, trap, or reservoir, and intended as a receptacle of the flame, hot air, and smoke, after they have quitted the furnace, and passed through the small aperture as above described. This space, or reservoir, for the flame, hot air, and smoke, being closed at the top and external sides, and open only at the bottom outwards, for the purpose of permitting the smoke, &c. to pass off into the chimney, still farther checks and detains the flame and hot air in the furnace; and being itself constantly full of warm air, smoke, &c. causes the heat to be reverberated against the sides and bottom of the vessel or boiler, and effectually prevents the admission of the cold atmospheric air from the chimney, which, on the old plans of construction, is found by experience to rob the furnace and vessel of more than half the supply of heat which any given quantity of fuel is capable of yielding. The valves, sliders, and dampers, are not essential parts of the invention, but merely as regulators, which, in many cases, may be altogether omitted, without detriment to the operation of the fire.

Count Rumford has successfully extended his researches to discover the most economical plan in the management of fire, and the generation of heat for culinary and other purposes, and thinks that the fire cannot be made to impinge against the sides of a vessel with the same force and effect as against the bottom: which is a plain proof, that at the time of writing that essay, he was totally unacquainted with Mr. Rowntree's method of applying and managing the fire; in which the very effect which the count considers as a *desideratum* in science, and which appears to have been one grand object of his philosophical pursuits, is now in a great measure completed. See Kitchen.

BOILING, in the culinary art, is a method of dressing animal food, vegetables, &c. by decoction in hot water, for the purpose of removing their natural crudities, and rendering them more easy of digestion. By too much boiling, however, flesh is deprived of a considerable part of its nourishing juice, as the gelatinous substance of the meat is extracted, and incorporated with the water, while the spiritous and balsamic particles are dissipated by evaporation. The culinary process of *stewing* is more profitable, especially if conducted in close vessels, as it is better calculated to preserve and concentrate the most substantial and nutritious parts of animal food.

BORAX, or *Sub-Borat of Soda*—Borax is a saline substance found in Tibet and China; in the former place it is procured from a lake situated among the mountains, fifteen days journey from Tisoolumbo the capital, and entirely supplied by springs, no streams either falling into or flowing from it. The water has a salt taste and contains both borax and common salt, and on account of its elevated situation is frozen for a great part of the year. The edges and shallows of the lake are covered with a stratum of borax, which is dug up in considerable masses, and the holes thus made are gradually filled by a fresh deposition: from the deeper parts of the lake common salt is procured. The borax in its rough state is called tincal, and is brought to Europe in the form of a brownish-grey impure amorphous salt, or in detached crystals about an inch in length, of a pale greenish hue, and in the form of compressed hexahedral prisms.

The purification of borax is an art which was first discovered by the Venetians, afterwards passed to the Dutch, and is now practised in great perfection by some English and French chemists. The process is as yet kept a secret, but in all probability consists of calcination, solution and crystallization. Chaptal, however, informs us, from his own extensive experience, that the destruction of the oily part of borax by calcination is attended with considerable loss. He finds, after trying all the processes in the large way, that the simplest method consists in boiling the borax strongly, and for a long time, with water. This solution, being filtered, affords by evaporation crystals, which are somewhat foul, but may be purified by repeating the operation. The crude borax is often covered with an oily or greasy matter to prevent it from efflorescing

and on this account is not easily acted on by hot water. It appears however that by exposing the tincal to a calcining heat lower than its point of fusion, the grease may be burnt off and the other inflammable impurities got rid of; the residue being then reduced to a fine powder and digested in boiling water, the saline parts will be dissolved, leaving most of the impurities behind.

Borax when quite pure is in colourless crystalline masses, very slightly efflorescent on exposure to the air; but when exposed to a dry heat speedily dissolves in its water of crystallization, it then, as the moisture evaporates, becomes of an opake white colour, and a voluminous spungy texture like burnt alum. If the heat is encreased to a moderate redness it liquefies, and when cool appears as a colourless transparent glass. If poured out of the crucible in order to cool, it should be transferred as soon as it becomes solid to a covered bason or other proper vessel, for it always cracks and flies to pieces before it grows cold. Borax when thus fused is called glass of borax. By exposure to the air it acquires the appearance of chalcedony on account of the partial efflorescence that it undergoes. If made in a silver crucible, or if *hastily* melted in an earthen one, it is perfectly resoluble in water, but when kept fluid for a long time in a common crucible it dissolves a portion of the earth of the vessel and becomes little if at all soluble in water.

Borax is decomposable by all the mineral and vegetable acids. Silex and alumine combine in the dry way with borax, the former into a transparent, the latter into an opake glass. If the ingredients are in nearly equal proportions the glass is insoluble in the mineral acids, but if a considerable excess of borax is employed, the result is a soluble glass. Of this circumstance Mr. Chenevix has ingeniously taken advantage, by substituting borax for caustic potash in the analysis of the more refractory stony compounds, the use of the former salt being on many accounts much more convenient than that of the latter. Borax will also dissolve most of the metallic oxyds, receiving from each of them peculiar tinges of colour.

The uses of borax are considerable: it is employed in the laboratory as a very active flux, and as producing a more perfetly limpid fusion than any other substance. For the same reason it is an ingredient in some of the finer kinds of glass; though its dearness prevents it from being employed so often as it otherwise might be to great advantage. Borax is also highly useful to the jewellers and goldsmiths as a flux for the solder by which pieces of gold and silver are cemented together; in the East Indies it is employed in the moist way as a solvent for gum LAC; and dyers frequently employ it for giving a gloss to silks.

Borax is not only found in the East Indies but likewise in South America. Mr. Anthony Carera, a physician established at Potosi, informs us, that this salt is abundantly obtained at the mines of Riquintipa and those in the neighbourhood of Escapa, where it is used by the natives in the fusion of copper ores.

BRANDY. This valuable spirit is produced by the distillation of wines of all kinds, and properly speaking, by no other fermented liquor whatever. Under the article ALCOHOL we mentioned that the purely spirituous part of all fermented liquors appears to be identically the same. Brandy, rum, corn spirits, &c. being the products of the first distillation from fermented liquors, and alcohol the purer part of each, being separated by a quent process.

Brandy is prepared in many of the wine countries of Europe, and with particular excellence in many parts of the centre and south of France. The necessary process is extremely simple, being nothing more than a well regulated distillation of wine without addition, from suitable vessels; but to alter or improve the colour and flavour, various substances are added to the spirit after distillation. The manufactory is technically called in France *Brulerie*, and the makers, *Bruleurs d'Eau de Vie.*

Though every wine will give a certain portion of brandy by distillation, some are much preferable to others. In general the strong heavy wines yield the most spirit, giving nearly a fourth of good proof spirit, whilst some of the light thin wines furnish no more than about a fifteenth. If the quantity is less than a sixth it will hardly repay the expense of distillation.

French brandy acquires by age a great degree of softness, and at the same time a yellowish brown colour, which our distillers have imitated in their artificial preparations. But this colour being found only in such brandies as have become mellow by long keeping, it follows that the ingredient, from which it is extracted, is the wood of the cask, and that the brandy in reality has received a tincture from the oak. The peculiar flavour which French brandies possess, is supposed to be derived from an essential oil of wine, mixed with the spirit; but, more probably, it originates from the

very nature of the grape, or the wine lees.

It deserves to be remarked, that our distillers frequently make use of the *spirit of nitrous ether*, commonly called, dulcified spirit of nitre : a very small proportion of which, added to pure whiskey, or a liquor obtained by the distillation of malt, imparts to it a flavour, not unlike that of French brandy.

A vinous spirit has been extracted from carrots by Mr. Thomas Hornby, of York, (England,) who found, that an acre of carrots (20 tons,) produced 240 gallons of spirit; which is considerably more than can be obtained from five quarters of barley, the average produce of an acre.

Brandy, even of the most genuine kind, is less wholesome than rum; but the counterfeit and adulterated sorts are exceedingly detrimental to those who are habitually addicted to the use of this pernicious liquor. It should, therefore, be drank very moderately, rather from necessity than for gratification.

Excellent brandy is made from apples in the United States, notwithstanding what Chaptal has said on the subject. If carefully distilled from sound apples, and kept a few years in a warm situation, it is very agreeable when diluted with water. Peaches also yield a liquor, which, when properly distilled, is by many preferred to the finest French brandy.

The following recipe for making apple brandy, was communicated by Mr. Joseph Cooper, of New Jersey. The liquor made agreeably to this process, is mild, mellow, and pleasant, and greatly superior to apple spirits procured by the common mode.

"Put the cider, previously to distilling, into vessels free from must or ill smell, and keep it till in the state which is commonly called good sound cider, but not till sour, as that lessens the quantity and injures the quality of the spirit. In the distillation, let it run perfectly cool from the worm, and in the first time of distilling, not longer than it will flash when cast on the still head and a lighted candle applied under it. In the second distillation, shift the vessel as soon as the spirit runs below proof, or has a disagreeable smell or taste, and put what runs after with the low wines. By this method the spirit, if distilled from good cider, will take nearly or quite one third its quantity to bring it to proof; for which purpose take the last running from a cheese of good water cider, direct from the press, unfermented, and in forty-eight hours the spirit will be milder and better flavoured than in several years standing if manufactured in the common way. When the spirit is drawn off, which may be done in five or six days, there will be a thin jelly at bottom, which may be distilled again, or put into the best cider, or used for making royal cider: it being better for these purposes than the clear spirit, as it will greatly facilitate in refining the liquor."

One wine glass full added to a half gallon bowl of punch, highly improves the flavour of that drink. In Virginia, peach brandy has long been distilled, and might be made a very profitable article of internal commerce, as the peach tree appears to thrive better in that state, than in almost any other in the Union. See DISTILLING.

BRASS, in metallurgy, is a factitious metal, made of copper and zinc, or *lapis calaminaris*.

By long calcination alone, and without the mixture of any other substance with it, brass affords a beautiful green or blue colour for glass: but if it be calcined with powdered sulphur, it will give a red, yellow, or chalcedony colour, according to the quantity, and other variations in using it.

Brass colour, is that prepared by colourmen and braziers to imitate brass; of which there are two sorts: namely, the red brass, or bronze, which is mixed with red ochre, finely pulverized; and the yellow, or gilt brass, which is made of copper filings only. Both sorts are used with varnish.

Corinthian brass, is a mixture of gold, silver, and copper; so called from the melting and running together of immense quantities of those metals, when the city of Corinth was sacked and burnt, 146 years before Christ.

In 1781, a patent was granted to Mr. James Emerson, for his invention of making brass of copper and zinc. The Patentee directs the spelter to be melted in an iron boiler, then passed through a perforated ladle and placed over a vessel containing water; by which means the zinc will be granulated. Fifty-four pounds of copper shot are now annexed with 10lbs. of calcined and pulverized calamine, together with about one bushel of charcoal: a handful of this mixture is first put into a casting-pot, then 3lbs. of the granulated zinc; upon which the composition before specified is laid till the vessel is filled: Mr. Emerson, however, has not stated the exact proportion of the ingredients. Eight similar pots are now to be supplied with the same materials, and the whole must

be submitted to the heat of a furnace, for the space of 12 hours; when the process will be completed and 82lbs. of brass be procured; which the Patentee asserts to be of a very superior quality to that manufactured from copper and calamine.

Various articles made of brass have sometimes an appearance of well gilt metal. This appearance, we now know, is produced by means of a solution of gum-lac in spirit of wine, with which they are rubbed. As long as the lac lasts, they retain their splendour. These articles, however, are attended with one inconvenience, that they must never be cleaned with a strong brush, or scoured with chalk or whiting, but only wiped with a soft rag; for as soon as the lac is rubbed off they loose their brilliancy. A varnish of this kind may be prepared in the following manner:

Dissolve two ounces of very pure and fine gum lac in forty-eight ounces of alcohol, and place the solution in a sand bath exposed to a moderate heat. To prevent the too abundant evaporation of the spirit of wine, as well as the bursting of the glass, a piece of bladder ought to be bound over the latter, and a few holes made in it with a needle. In another glass, dissolve in the same quantity of spirit of wine, an ounce of dragon's blood in grains. When both the solutions are completed, mix them together, then put three grains of yellow wood into it, and suffer it to remain there twelve hours in a moderate heat: after which, strain the liquor through filtering paper, and preserve it for use in a clean glass bottle. To give this lac-varnish a high gold colour, yellow wood is preferable to every other substance. If the varnish be intended to be pale, and not to change the colour of the brass, the yellow wood may be omitted, but if a stronger colour be required, a half more of the yellow wood may be added.

The uses of brass are too numerous to be mentioned. It is applicable to an infinite variety of purposes, is easily wrought by casting and hammering, and by the lathe; its wire is eminently useful, and it takes a high and very beautiful polish The appearance of brass is given to other metals by washing them with a yellow lacquer or VARNISH, a substitution often very much to the detriment of the manufactured article.

Many other yellow alloys of copper are used, such as bronze, bell-metal, &c. most of which are triple compounds, and will be noticed under the article COPPER.

BREAD, an important article of food, prepared of flour kneaded with a mixture of yeast, water, and salt, and afterwards baked in an oven.

Before the invention of mills for grinding corn, bread was prepared by boiling the grain, and forming it into viscous cakes, not very agreeable to the palate, and difficult of digestion. In process of time, machines were constructed for grinding corn, as well as for separating the pure flour; and a method was discovered to raise the dough by fermentation. Dough may be fermented either by *leaven* or by *yeast*; but as the latter raises the kneaded mass more uniformly, and produces the sweetest and lightest bread, it is generally preferred. Bread well raised and baked is not only more agreeable to the taste than unfermented bread, but more readily mixes with water, without forming a viscous mass, or puff, and is at the same time more easily digested in the stomach.

Bread [in England] is divided into three kinds, namely, white, wheaten, and household. Fine white bread is made only of flour; the wheaten contains a mixture of the finer part of the bran; and the household of the whole substance of the grain.

Although we have, in the article BAKING, given general directions for successfully conducting this complicated process, yet we think it will be useful, in this place, to add, by way of supplement, a few particulars relative to this subject, and more especially applicable to domestic purposes. Mr. Dossie, who appears to have paid great attention to the art of baking, gives the following simple and much approved method of making good white bread: Take of fine flour, six pounds; of water, moderately warm, but not hot, two points and a half; of liquid yeast, eight spoonsful; and of salt, two ounces. Put about a pint of the warm water to the yeast, and mix them well, by beating them together with a whisk. Let the salt be put to the remaining part of the water, and stirred till completely dissolved. Then put both quantities of the fluid gradually to the flour, and knead the mass well till the whole is properly mixed. The dough thus made must stand four or five hours, that is, till the exact moment of its being fully risen, and before it is sensibly perceived to fall. It is then to be formed into loaves, and immediately placed in the oven. To bake it properly, is attended with some difficulty to those who are not skilled in the art. The first care is to see that the oven be sufficiently heated, yet not to such a degree as to burn the crust. If a green vegetable turns black when put

in, the oven will scorch the bread; in which case it must stand open till the heat has somewhat abated. The next circumstance to be attended to is, that the mouth of the oven be well closed, till the bread has risen to its full height, which will not take place in less than 2 or 3 hours. After this, but not before, the oven may be opened for the purpose of viewing the bread, and seeing that it is baked without being either burnt, or too crusty; for if the mouth of the oven be not kept closely stopped till the bread is fully risen, it will flatten and become heavy. When properly managed, the above mentioned ingredients will have lost about one pound two ounces in weight, so that a well-baked loaf of this kind should amount to seven pounds twelve ounces.

Bread may be made *without yeast*, as is practised in Hungary, by the following process: Boil two good handsful of hops in four quarts of water; pour the decoction upon as much wheat bran as the liquor will moisten. Then add four or five pounds of leaven; mix the whole together, till perfectly united. Put this mass into a warm place for twenty-four hours; then divide it into pieces about the size of a hen's egg; let these be dried in the air, but not in the sun, and they will keep good for six months Or, make the above into six large loaves, take six good handsful of dough, broken small and dissolved in eight quarters of warm water, and poured through a sieve into one end of the bread-trough; then pour three quarts more of warm water through the sieve after it, and what remains in the sieve must be well expressed.

To make bread with salt.—Take as much salt as is necessary to a loaf of the size intended, dissolve it in as much warm water as will mix the flour. Set it in a pot at a distance from the fire, sufficient to warm, but not to bake the flour on the side of the pot; a yellow water will rise on the top, which take off with a spoon, and the rising will begin. Then mix it with as much flour, as will make the loaf, and if it should not be sufficient add a little warm water; in less than an hour it will be fit to bake. From the time the salt water and flour are mixed, three or four hours are required. The mass does not rise like bread made with yeast. The editor has tasted bread made agreeable to the above recipe, and found it pleasant and light.

Mr. Ferryman, of England has invented a machine for separating the outer coat or bran of wheat, without loosing the internal coat, which adheres to the outer, and has always hitherto been thrown off with the former in grinding. It is asserted that this second coat, is highly nourishing and gives a sweetness to bread, which it never has, when made from common flour. The late Duke of Bedford bore testimony before a committee of the house of commons, of the superiority of bread made of grain thus blanched. The only objection which can be made to such bread is that it is of a darker hue than common bread.

One hundred pounds weight of flour will make from 134 to 138½ pounds of bread.

In an experiment made to ascertain the number of loaves of bread which a barrel of flour will produce, it appeared that 3½lb. of flour produced 4 lb. 9 oz. of good light bread. This is an increase of about 40 per cent. Therefore, a barrel of flour will make 372½lbs. of bread, which will produce 312 loaves, weighing 14 oz. and at 6 cents, or $\frac{1}{10}$ of a dollar, yield 19\cdot\frac{50}{100}$

A machine for kneading flour is used in the public baking houses at Genoa, and is calculated to save much labour. An account of this machine, together with a plate may be found in Nicholson's *Phil. Jour* and the *Rep. of Arts*; taken from the *Trans. of the Pat. Society of Milan*, vol. 2.

Like all other farinaceous substances, bread is very nourishing, on account of the copious mucilage it contains; but, if eaten too freely, it is in weakly habits, productive of viscidity which obstructs the intestines, and lays the foundation of habitual costiveness. Leavened bread, or such as has acquired an acidulated taste by a slow fermentation of the dough, is cooling and antiseptic. By this process, all the viscous are combined with the drier parts of the flour, and the fixed air is expelled in baking. New baked bread contains a large proportion of indigestible paste, which may be rendered less unwholesome by allowing it to dry for two or three days, or by toasting it. This mode ought to be adopted, both on account of health and economy, especially in times of scarcity. Stale bread, in every respect, deserves the preference to that which is newly baked; and persons troubled with flatulency, cramp of the stomach, or indigestion, should abstain from new bread, and particularly from hot rolls.

Various substances have been used for bread, instead of wheat. In the years 1629 and 1630, when there was a dearth in England, bread was made in London of turnips, on the recommendation of Dr. Beale. In 1693 also, when corn was very dear, a great quantity of turnip-bread was made in several parts of the kingdom, but particularly in Essex, by a receipt registered in the *Philosophical Transactions.*

The process is, to put the turnips into a kettle over a slow fire, till they become soft; they are then taken out, squeezed, and drained as dry as possible, and afterwards mashed and mixed with an equal weight of flour, and kneaded with yeast, salt, and a little warm water.

The following is another method of making bread of turnips, which deserves to be recommended for its cheapness: Wash clean, pare, and afterwards boil a number of turnips, till they become soft enough to mash; press the greatest part of the water out of them, then mix them with an equal weight of wheat-meal, make the dough in the usual manner with yeast, &c. it will rise well in the trough, and, after being well kneaded, may be formed into loaves and put into the oven. Bread prepared in this manner has a peculiar sweetish taste, which is by no means disagreeable; it is as light and white as the wheaten, and should be kept about twelve hours before it is cut, when the smell and taste of the turnip will scarcely be perceptible

Potatoes have also been made into bread, by different processes. The simplest is to choose the large mealy sort, boil them as for eating, then peel and mash them very fine without adding any water. Two parts of wheat flour are added to one of potatoes, and a little more yeast than usual. The whole mass is to be kneaded into dough, and allowed to stand a proper time to rise and ferment, before it is put into the oven. Bread thus prepared is good and wholesome; and if bakers were to make use of no worse ingredients than this nutritive root, they might be justified in times of scarcity, provided they sold it at a moderate price, and under proper limitations.

M. Parmentier found, from a variety of experiments, that good bread might be made of equal quantities of flour and potatoe meal. He also obtained well-fermented bread of a good colour and taste, from a mixture of raw potatoe-pulp and wheaten meal, with the addition of yeast and salt.

Dr. Darwin asserts, that if eight pounds of good raw potatoes be grated into cold water, and after stirring the mixture the starch be left to subside, and when collected, it be mixed with eight pounds of boiled potatoes, the mass will make as good bread as that from the best wheaten flour. He likewise observes, that hay, which has been kept in stacks, so as to undergo the saccharine process, may be so managed, by grinding and fermentation with yeast, like bread, as to serve in part for the sustenance of mankind in times of great scarcity. As an instance of the very nutritive quality of hay, it is mentioned, that a cow, after drinking a strong infusion of it for some time, produced above double the usual quantity of milk. Hence, if bread cannot be made from ground hay, there is reason to believe, that a nutritive beverage may be prepared from it, either in its saccharine state, or by fermenting it into a kind of beer.

There are other vegetables, says Dr. Darwin, which would probably afford wholesome nutriment, either by boiling, or drying and grinding them, or by both these processes. Among these may be reckoned perhaps the tops and bark of gooseberry-trees, holly, gorse, and hawthorn. The inner bark of the elm may be converted into a kind of gruel, and the roots of fern, and probably those of many other plants, such as grass or clover, might yield nourishment either by boiling, baking and separating the fibres from the pulp, or by extracting the starch from those which possess an acrid mucilage, such as the white bryony.

The adulteration of flour and bread has often been the subject of animadversion. Mealmen and millers have been accused of adding chalk, lime, and whiting to the flour, and bakers of mixing alum with the dough. There is much reason to suspect, that these practices are but too prevalent.

It has been asserted, that the adulteration of bread is owing to the legal distinctions in the quality of it, and to our making colour the standard of goodness. Dr. Darwin observes, that where much alum is mixed with bread, it may be easily distinguished by the eye: when two loaves so adulterated have stuck together in the oven, they break from each other with a much smoother surface, where they had adhered, than those loaves do, which contain no alum.

An excellent method of making bread of rice is, by boiling three-fourths of wheaten flour and one fourth of rice separately. The rice should be well boiled, the water squeezed out (which may be afterwards used as starch for linen, for there can be no better), and the mass should then be mixed with the flour. It is made in the same manner as common bread, and is very nutritive. One pound and a half of flour mixed with half a pound of rice, will produce a loaf weighing from three pounds to three pounds two ounces, which is greater than that obtained by baking bread of wheat flour only. Rice has also been tried in the same proportion with barley, and makes good bread for

labouring people; but the gain in baking is by no means equal to that obtained by mixing it with wheat.

Another mode of preparing bread with bran, is as follows: "Take seven pounds seven ounces of bran and pollard, and fourteen quarts of water, and boil the whole very gently over a slow fire. When the mixture begins to swell and thicken, let it be frequently stirred, to prevent its boiling over, or burning either at the bottom or sides of the vessel. After having boiled two hours, it will acquire the consistence of a thin pudding. Now put it into a clean cloth, and squeeze out the liquor: take a quart of this, mix it with three pints of yeast, and set the sponge for twenty-eight pounds of flour. The mass, bran, and pollard, even after the liquor has been separated, will be found to be above four times its original weight; it is then to be placed near the fire. In about two hours, the sponge will have sufficiently risen. The bran and pollard, then lukewarm, should be mixed with the flour; and, after adding half a pound of salt, the whole must be well kneaded, with one quart of the bran liquor. Thus prepared, the dough is formed into loaves, and baked for two hours and a quarter in a common oven. The bread, when cold, will weigh one-half more than the same quantity of flour would, without the addition of the bran.

If the bran-water only is used, and the bran itself (which, by the boiling, increases considerably in weight) is not added to the dough, the increase of bread will still be considerable; but not more than one-third of the increase obtained, when all the bran is used.

It is known that rice gains greatly in boiling; and hence, when made into bread with flour, is highly economical, as will appear by the following experiments: Six ounces of rice were boiled in a quart of water, till it was dry and soft, and two pounds of flour were then added, and the whole, with two table spoonsful of yeast well worked into dough together, with the usual quantity of salt, giving it rather longer time to rise, which it was found it required—The loaf thus made, when baked, was light in quality, sweeter and more palatable than the common bread, and produced three pounds, seven ounces and a half.

From this experiment the following fact appears, that rice gains in weight in a double proportion to that of any other grain. This will be further seen by the following statement:

	oz.
2 pounds of flour	32
Rice	6
	38
Bread produced	55½
Deduct per contra	33
Gained	17½
To make a quartern loaf are generally used three pounds and an half of flour, ...	56
When baked, is by standard to weigh four pounds five ounces eight drachms, . . .	69½
Deduct as per contra	56
Gained	13½

Therefore the difference is, that two pounds of flour and six ounces of rice, produce four ounces weight more than three and a half pounds of flour—Two pounds of flour, and six ounces of rice boiled till it was quite dry and soft, produced four pounds twelve ounces of excellent bread—One pound of flour, and three ounces of rice, wet with bran-water, produced one pound twelve ounces of bread.

Another experiment—In doubling the quantity of rice to the same quantity of flour, it was found to answer for immediate consumption, but would not answer for general purposes; it may be safely concluded, that one-fifth of rice may be used with flour to great advantage to the public, by increasing the sustenance, and with profit to the baker, who can afford to sell it at 1½d. under the assize, and gain double what he does by baking the standard bread.

In making the foregoing experiments, it was proved, that nine-tenths flour and one-tenth rice, and in the same way as directed for making bread (except using yeast and salt) produced a finer crust in pastry than using flour alone.

Bread thus made keeps longer moist than wheaten bread, and is better the second day than the first. Rice may be steamed rather than boiled; and if the quality of the rice is good, half a pound steamed in a little more than a quart of water, till it is quite dry and soft, gains two pounds, that is, four-fifths in weight.

French bread is prepared in the following manner: Take half a bushel of the best wheaten flour, and dilute one pint of good yeast with three quarts of warm water; mix the whole properly, and cover it with flannel, till the sponge be formed. After the dough has sufficiently risen, six quarts of lukewarm skimmed

milk, and one pound of salt, are to be worked in, with the fingers, till the sponge be weak and *ropy:* when it must again be covered, and kept warm. The oven being now made very hot, and the paste moulded into bricks or rolls, they are put in expeditiously; the former requiring one hour and a half; but the latter only half an hour. As soon as the bread is baked, it must be drawn; and, if burnt, the black crust should be rasped—When the milk is added to the sponge, two ounces of butter are sometimes incorporated; but this addition being immaterial, it may be omitted.

The great advantage of eating pure and genuine bread must be obvious. Every part of the wheat, which may be called flour, was not only intended to be eaten by man, but it really makes the best bread, since that may be called the best which is of most general use, and so fine as to contain no part of the husks of the grain. But the delusion, by which so many persons are misled, to think that even the whole flour is not good enough for them, obliges them to pay a seventh or eighth part more than they need, to gratify a fanciful appetite. Had it not been for the custom of eating whiter bread than the whole of the flour will make, the miller and baker would not have employed all their art to render the bread as white as possible, and make the consumer pay for this artificial whiteness.

New Substitutes for Flour or Bread.—We have, in the preceding analysis, mentioned various substances which might advantageously be employed in the manufacture of this indispensable article of human sustenance; independently of the different kinds of grain and roots that are already made subservient to this beneficial purpose. In order to exhibit a distinct view of the most promising substitutes, whether indigenous or exotic, and especially such as have actually been used, on the authority of creditable evidence, we shall here divide them into three classes, and, in the course of the work, give a more particular account of each article, in its alphabetical order.

I. *Farinaceous Seeds.*—Wheat-grass, Millet, Common Buck-wheat, Siberian Buck-wheat, Wild Buck-wheat, Wild Fescue-grass, Maize, or Indian Corn, Rice, Guinea Corn, or White Round-seeded Indian Millet, Canary-grass, Rough Dog's-tail Grass, Water Zizany, Upright Sea Lime-grass, Sea-reed, Marram, Helme, or Sea Mat-weed.

The following mealy fruits, however, deserve a decided preference over many of the preceding: viz. Water Caltrops, or the fruit of the Pulse of various kinds, such as Peas, Lentils, Beans, and the seeds of the Common Vetch, Fetch, or Tare-acorns. and especially those of the *Quercus cerris* and *esculus;* the seeds of the White Goose-foot, Common Wild Orange, or the *Chenopodium Album;* the seeds and flowers of the Rocket, of the Sorrel, of the different species of Dock, of the Yellow and White Water-lily, of the Corn-spurrey, or of the Spinage, of the Common Gromwell, or Graymill, of the Knot-grass, the Beech-nut, (see BEECH-MAST OIL,) the husks of the Lint-seed, &c.

II. *Farinaceous Roots:* namely, those of the Common and Yellow Bethlem Star, of the Yellow Asphodel, of the Wake Robin, (after being properly dried and washed) of the Pilewort, or Lesser Celandine, of the Common Dropwort, of the Meadow-sweet, of the White Bryony, of the Turnip-rooted Cabbage, of the Great Bistort, or Snake-weed, of the Small, Welch, or Alpine Bistort, of the Common Orobus, or Heath-Pea; the Tuberous Vetch; the Common Reed; both the Sweet-smelling and Common Solomon's Seal; the Common Corn-flag, the Salt-marsh, Club-rush, &c.

III. *Fibrous and less juicy roots:* viz. those of the Couch-grass, or Creeping Wheat-grass; the Clown's or Marsh Wound-wort, the Marsh Mary-gold, or Meadow-Bouts; the Silver-weed, or Wild Tansey; the Sea Seg, &c.

Having thus stated the various substitutes for bread, which have either already been adopted with success, or which might, in times of *real* scarcity, be easily converted into proper nutriment, we cannot better conclude this article than in the words of Arthur Young, Esq. who, in his Observations on the late Royal Proclamation, recommending frugality in the consumption of corn as one of the surest and most effectual means of alleviating the present pressure of the times, espouses the cause of the unfortunate poor, nearly in the following words: Every master or head of a family is in duty bound to second, without compulsion, the humane views of the legislature. Hence, bread made of the whole produce of the wheat, excepting only seven pounds of the bran in each bushel, and adding one-fourth or third part of a substitute, would probably be the most effective saving. If the consumption of the whole kingdom of Great Britain be computed at 8,000,000 of quarters in twelve months, this saving on all the wheat consumed in nine months would be 700,000 quarters, which would feed 875,000 persons, at the ordinary consumption of one quarter a head per an-

num; and probably be equal, under the present restricions, to afford food to 1,000,000 of people for the next nine months—Farther, if the saving of oats to the supposed number of 500,000 horses of luxury, be calculated only at 1 bushel per week, this would, in 9 months, amount to 18,000,000 of bushels; or sufficient to support 1,000,000 of persons for the same period of time, allowing to each not less than twenty-five bushels per annum.....With due deference to Mr. Young's statistical information, however, we beg leave to doubt whether 500,000 fat horses, crammed on the food of man, move about the country; though it must be acknowledged, that *pleasure horses* "are spectacles of envy to the starving poor—abominable and scandalous spectacles, which, in times of scarcity, ought to be removed from the view of those whose miserable children might be fed on the corn thus saved."

BREEDING *of Cattle:* As the different circumstances to be attended to in the management of cattle, has been stated when treating of domestic animals, we shall here only observe, that the first thing to be considered is *beauty of form;* the next is proportion of parts, or what may be called *utility of form;* the third, which has engaged the attention of midland breeders, is the texture of the muscular parts, or what is called *flesh;* a quality which, however familiar it may have been to the butcher and consumer, has not in general been attended to by breeders. In short, it is a rule applicable to all sorts of live-stock, to breed from straight backed, round bodied, clean, small boned, healthy animals: carefully rejecting such as have roach backs and heavy legs, with much external appearance of offal, &c.

To the late Mr. Bakewell of Dishley, England, who was undoubtedly the most scientific breeder of his time, we are indebted for many new and important improvements in the art of breeding cattle. His principle was to procure the best beast, that would weigh most in the valuable joints; and thus, while he gained in point of shape, he also acquired a breed much hardier, and easier fed than any other.

With respect to the breed of oxen, Mr. Bakewell asserts, that the smaller the bones, the more perfect will be the make of the beast, and the quicker it will fatten. The breed preferred, and considered by him as the best in England, is that of Lancashire. The shape which should be the criterion of a cow or bull, an ox, or a sheep, is that of a hogshead, or a firkin with legs as small and short as possible. He found from various experiments in different parts of England, that no land is too *bad* for a *good* breed of cattle, and particularly of sheep. The great advantage arising from his breed is, that the same quantity of food will suffice them, much longer than it will any other kind; besides which, the wool is of the finest quality, and the sheep stand in the fold perfectly well.

The wintering of cattle also received particular attention from this professional breeder: his horned beasts were tied up during the winter, in sheds, and fed with straw, turnips, or hay; all the lean beasts were fed with straw alone, and lay without litter. Young cattle, that require to be kept in a thriving state, are fed upon turnips; and as the spring advances, and this vegetable becomes scarce, hay is their only food.

The floors, on which the cattle stand, are paved, and raised six or eight inches above the level of the yard; and each crib being only broad enough for a beast to stand on, its dung falls on the lower pavement; by which contrivance it is kept perfectly clean without litter.

Little attention has been paid to the preservation of a good breed of cattle in the United States. Some with excellent qualities, have been imported, and are occasionally met with; but they are in general fattened and killed, instead of being carefully preserved for breeding cattle. But this is not the way to improve. It was by a practice directly the reverse that Bakewell brought his breed to unrivalled celebrity.

Droves of cattle are annually brought to Philadelphia from New England and North Carolina. The former are larger and more profitable than the latter, which are generally small, and wild from having been fed in the woods.

Several very large cattle have been fed and killed within a few years in Philadelphia. They have in general been raised near Elizabeth-town, New-Jersey, but whether from a native or imported stock is unknown. The following are the weights of a few of these beasts:

1. A Cow raised by the late Mr. Hiltzheimer, of the city of Philadelphia, and killed on the 2d of March, 1787.

The fore-quarters weighed, (one) . . .	326 lbs.	
The other,	328	lbs 654
The hind-quarters weighed, (one)	282	
The other,	289	571
The nett Beef		1225

		lbs.
Brought forward		1225
The Hide weighed . . .	111	
Head and Heart . .	49	
Belly and Feet . . .	72	
Fack	35	
Tallow	163	430
Entire weight (exclusive of guts) . .		1655

2. A five year old steer, fed by Mr. Seckel, of Philadelphia, a few years since, one summer and one winter, weighed alive, 1,494¾ lbs.

The belly fat . . 278 lbs.
Kidney do 100

3. Ten head of cattle, fed by the same gentleman, produced 2,439 lbs. of belly and kidney fat, with one summer feeding on grass.

4. A steer, raised at Tulpehocken, was killed on the 12th March, 1787, weighed alive, 2,184 lbs.

5. A steer raised at Haddonfield, New-Jersey, killed at Philadelphia, on the 7th April, 1787, weighed alive, 2,140 lbs.

Formerly a great prejudice prevailed in favour of large beasts, but it has been ascertained that this large big boned breed is not so profitable as the *middle sized, barrel shaped, short legged kind.* Much may be done towards improving the breed by a careful attention to stock. Mr. Bakewell and his disciples relied upon a *kindly skin,* as a principal point in the choice of a beast. By that is meant a skin that feels soft, though firm to the touch, which is equally distant from the hard dry skin, peculiar to some cattle, as from the loose and flabby feel of others.

Some breeds have a tendency to generate fat on certain parts of the body in great quantities, while others have it more mixed with the flesh of every part of the body. These particulars demand the attention of improvers.

The first object that naturally offers to be attained, is the possession of a breed of cattle, which, with a given quantity of food, will afford the quickest and greatest return of the most valuable parts of flesh, or of milk or butter. After repeated experience and close attention to the subject, by European improvers, it has been found, that so far as flesh is concerned, there are certain forms and proportions of body, intimately connected with the great object in view, and these shall now be detailed.

2d. Of a Bull.—The head should be rather long, and small, muzzle fine, chaps clean, eyes lively and prominent, ears long and thin, horns tapering, bright and spreading; *neck fine,* rising with a gentle curve from his shoulders, and small and fine where it joins the head, progressively leading down to a full and deep bosom; shoulders moderately broad at the top, joining full to the chine crops and chest; breast broad, and projecting well before his legs; his arms or fore-thighs muscular and tapering to his knee; his legs clean, straight, and very fine boned, and standing wide; his chine and chest so full as to leave no hollows behind the shoulders, the plates strong, to keep his belly from sinking below the level of his breast; his back or loins broad, straight and flat; his ribs rising one above another, in such a manner that the last rib shall be rather the highest, leaving only a small space to the hips, the whole forming a round, barrel-like, but capacious carcase: his hips should be wide, round, and a little higher than the back; the rump wide, and lying in a horizontal direction, and not sinking backwards, but even with the general level of the back; the huckle bones and rump bones not in the least protuberant; the tail should be thin, round and tapering, not hairy, and set on so high as to take in the same horizontal line with the back: it should moreover be broad at bottom, to prevent the appearance of the cavities at the nache: and the gristles at the setting on of the tail should rather project on each side, as they accumulate much fat in this part. The skin should be mellow and elastic, yielding pleasantly to the touch, especially on the chine, shoulders and ribs; feeling soft, though firm to the touch, equally distant from the dry hard skin, or loose flabby feel: finally, whatever the size of the animal may be, just and equal proportions of length, depth and substance, are the truest indications of vigour, and of the ability of the animal to produce and stand under the greatest possible load of flesh.

This improvement is to be effected by a conjunction of male and female, of the desired species, form, and properties; some steps being gained in every procreation. The male, of course, being able to multiply his likeness to such an extent, must be the prime instrument in the business: it is therefore of the utmost consequence that he be thorough-shaped, or thorough-bred: "That is, descended from a race of ancestors, who have, through several generations, possessed, in a high degree, the properties which it is our object to obtain. The female ought also to be selected with the strictest care, and, according to Mr. Cline, ought rather to be proportionally larger than the male, since the improvement depends on this principle, that the power of the female to supply her offspring with nourishment in pro-

portion to her size, and the power of nourishing herself from the excellence of her constitution. In this particular an error is very commonly committed, the attention being confined to the male. In the case of Horses, perfection in a great degree consists in the "wind" and this depends on parentage, and on the female most.

Some however, object to the principle laid down by Mr. Cline, respecting the advantages of propagating from large in preference to small females. "Nature," he says, "has given to the offspring of many animals, (those of the sheep, the cow, and the mare, afford familiar examples) the power, at an early age, to accompany their parents in flight; and the legs of such animals are very nearly of the same length at the birth, as when they have attained their perfect growth. When the female parent is large, and the fœtus consequently so, the offspring will be large at its birth, in proportion to the bulk it will ultimately attain, and its legs will thence be long comparatively with the depth of the chest and shoulders. When, on the contrary, the female is small, and the fœtus so, at the birth, the length of the legs of the young animal will be short comparatively with the depth of its chest and shoulders: and an animal, in the latter form, will be greatly preferable, either for the purposes of labour, or of food to mankind. This difference in the influence of the male and female parents on the offspring, has been very strikingly exemplified, in the result of an attempt to obtain very large mules from the male ass, and the mare. The largest females, that could be procured, were selected, and the forms of the offspring at the birth, were perfectly consistent with the theory of Mr. Cline; they were remarkably large, and the length of their legs, when they were only four days old, very nearly equalled that of the legs of their parents. The same animals when five years old, in the depth of their chests and shoulders, very little exceeded their male parent, (a Spanish ass) but from mares of small stature, were perfectly well proportioned.

"There is another respect in which the powers of the female appear to be prevalent in their influence on the offspring, and that is relative to its sex. In several species of domesticated, or cultivated animals, particular females are found to produce a very large majority, and sometimes all their offspring, of the same sex; and it has been proved repeatedly, that, by dividing a herd into three equal parts, a very large majority of females could be obtained from one part, of males from another, and nearly an equal number of males and females from the remainder. Endeavours have been made to change these habits, by changing the males, but always without success; in some instances, the offspring of one sex, though obtained from different males, exceed those of the other, in the proportion of five or six, and even seven to one. When, on the contrary, in the numerous offspring of a single bull, or ram, or horse, no considerable difference in the number of offspring of either sex, has ever been observed. We are therefore disposed to believe, that the sex of the offspring is given by the female parents.

To obtain the most approved form, two modes of breeding have been practised, one by the selection of individuals of the same family, called breeding, "in-and-in;" the other, by selecting males and females from different varieties of the same species, which is called "crossing the breed."

When a particular variety approaches perfection in form, breeding *in-and-in* may be the better practice. In following this, however, great caution is requisite in selecting the best shaped individuals. It was thus the celebrated *Bakewell* preserved his various stock, without degeneration in any of the qualities for which they were famous. But as, in the United States, the origination of a breed of neat cattle is to be aimed at, the system of crossing must be adopted, and for this end, the following rules should be attended to.

Individual variety of size and shape prevails in all breeds, to the infinite use and convenience of man. Some will run naturally to length and depth of carcase; others will have a tendency to the contrary form, or with much substance, wide loins, and short legs. The improving breeder, in joining the sexes, will take advantage of these varieties of shape or peculiar properties; increasing length and depth of carcase, when required, or moderating too great length with its opposite,—with rotundity of form, and width of loin, and shortness of leg; ever having especial regard to preserving *substance* in the form of his stock, and to prevent the increasing length and too near approach of the legs. It is very common for the best breeds to degenerate in this way from neglect; in which case it will be necessary to change the males for others of a still shorter and more substantial form, either from the same or a kindred variety, and to pay an increased attention to the selection of females.

Disposition.—It is of great importance to have a breed distinguished by a tame and docile disposition, without however being deficient in spirit. Such a breed is not so apt to injure fences, to break into fields, and unquestionably less food will rear, support and fatten them. As tameness of disposition is much owing to the manner in which the animal is brought up, attention to inure them early to be familiar and docile, cannot be too much recommended.

Hardiness.—This is a most important requisite. Even where stock is most attended to, it is of essential consequence that they should be as little liable as possible to disease, or any hereditary distemper, as being black fleshed, or having yellow fat. It is a popular belief that a dark colour is an indication of hardiness, and that cattle with light colours are softer and more delicate. A rough pile is also reckoned a desirable property in *outwinterers.*

Easily maintained.—On an attention to this point depends the profit, in a great measure, of the grazier. It is intimately connected with the shape above mentioned, and with smallness of bone In the horse, every one knows that a certain shape is indicative of being easily kept, and the remark will apply to neat cattle.

Early maturity.—Arriving soon at perfection is a material object for the breeder, as his profit must in a great measure depend upon it. Something will certainly depend upon their being fed in such a manner as to keep them constantly in a growing state: in this way they make more progress in three years, than they usually do in five, when they are half starved during winter, and their growth checked.

Quality of Flesh.—The quality of flesh most certainly depends much upon age and sex; heifers, for instance, must be finer grained than oxen; and the coarseness of stag beef is proverbial. The excellence of the meat also greatly depends upon their food, and the nature of the soil producing it. On the whole, there is no better sign of good flesh, than when it is marbled, or the fat and lean nicely and alternately mixed with each other.

Working.—In the case of working oxen, a quick step, and strength in proportion to speed, are of the greatest importance; and that these qualities may be imparted to an ox, there can be little doubt. In England, they are supposed to have been obtained by an admixture of the lighter, small boned French, Norman or Guernsey breed, with some of the native breeds. Their gentleness of disposition, mildness and hardihood, also serve to recommend the French breed. When well kept, they grow to good sizes, although naturally small. In the United States, a great diversity is found in respect to the gait of oxen; for while some are slow, others will walk nearly as fast as a horse. The formation of their fore-quarters, as before noted, will greatly influence their speed. If a breed could be originated, which, with the above mentioned qualities, this of quickstep were joined, a great object would be obtained, and would amply repay the breeder.

It may be asserted with safety, that in no country does the dairy-man receive greater prices for his milk, butter or cheese, than in the United States; and yet it is notorious, that the cows in general are far from excellent. The abundant provision required for the support of stock, during our long winters, ought to insure a plentiful supply of rich milk in summer, and yet it is believed that the profit from them is much smaller than is commonly imagined. We are much more deficient in this article of farm stock than in any other, which calls loudly for the attention of the improver. The indications of form, which so strongly characterise the profitable cattle for beef, fail with respect to milk, as we find that some of the most excellent milk breeds are very different in external form. The surest mode of procedure for the improver, is to breed from good milkers, that is, such as give rich milk, and if possible, from such as possess the forms approved of for bulls in the preceding pages, making allowance for the difference of sex. There are, however, some marks of a good milch cow, in every breed, which it may be useful to note; namely, a capacious and thin-skinned udder, large teats, with a large and distinct milk-vein; fine head and chaps, thin neck, shallow and light fore-quarters, capacious behind, wide loin, thin thigh, and white horns. A gaunt and meagre appearance of body, promising no great disposition to fatten, is added by some as a sign of a good milker; but although good milkers are often of a thin habit, yet there can be no reason why the rule should be absolute.

The combination of the valuable properties in a breed of milk and beef, is so important, and has been thought to be so difficult of attaining, that it has been recommended not to attempt the union, for in proportion as we gain in one point, we lose in the other. We know in general, that good milkers are seldom quick feeders. The two objects have however been accomplished to a certain extent in Eng-

land, in the case of the North Devon cows, and in some individuals of the Kyloe or Highland breed, and in the Suffolk Duns; and there is no reason why the same success should not attend equal industry in this country.

It is to be regretted that opportunities for the improvement of stock of neat cattle by means of the improved breeds of Europe are so few, and that even the knowledge of the existence of any among us is so partially diffused.

In the scarcity therefore of good foreign breeds, we must have recourse to our native stock, and it is a great satisfaction to know that there are excellent materials among us, on which we may commence the attempt. We every year see beasts of good form brought down in droves from various quarters, and sacrificed, after performing their duty for a season in a herd of cows; and which, if kept as breeders, would naturally improve the stock of the district. As a general rule, let no offspring be raised except from the finest boned, cleanest headed, straight backed, and best fleshed of every stock, both male and female.

The late colonel Pollen, a British officer, and well informed on the subject of cattle, passed through the United States in 1802, and mentioned in a note to a gentleman of Philadelphia, that he saw "a breed of cows near Lancaster, with a fine small head, smooth and delicate hair, small eye, round rib, and straight back, which would be an acquisition to England if introduced there." This remark, made by an intelligent foreigner, who was well acquainted with the improved breeds of England, ought to have its due weight, and should stimulate us to attend to the animals we meet with, which may possess some valuable properties.

A close adherence to these principles of choice at home, and in occasional purchase at markets, will soon convince any man how striking the improvement of his stock might become in a few years; and we look forward with great satisfaction to the period when the effects of our recommendation shall be shown.

Sir John Sinclair sums up the desirable qualities of cattle as follows.

1. A moderate size, unless when food is of a nature peculiarly forcing.
2. Shape the most likely to yield profit to the farmer.
3. Of a docile disposition, without being deficient in spirit.
4. Hardy, and not liable to disease.
5. Easily maintained, and on food not of a costly nature.
6. Arriving soon at maturity.
7. Producing considerable quantities of milk.
8. Having flesh of an excellent quality.
9. Having a tendency to take on fat.
10. Having a valuable hide. To which may be added,

Lastly, A quick step, and proportionate speed in working.

3d. *Of a Ram.*—The head should be fine and small; the eye prominent and lively, the ears thin, but not regular; the collar full from the breast and shoulders but tapering down; the shoulders should be broad and full, joining to the collar forward, and a chine backward in a straight line, so as to leave no hollow in either place; the mutton upon the fore thigh should come down to the knee, the legs should be straight, with a fine clean bone, free from superfluous skin and coarse hairy wool, from the hough and knee downwards: the breast should be broad, and project well before the legs: the fore legs should be wide asunder; the back and loins broad, flat and straight, and from the ribs should rise in a circular direction; the hind quarters should be long and full, with the mutton down to the hough, which should be wide and rather boning out. In the Merino race a rosy hue in the skin, and abundance of yoke or natural grease in the fleece, are peculiarities denoting health and high proof.

Wool is divided into two kinds, viz. long or combing, and the short or carding species; in both cases the thicker and finer the fleece the better. The particular species, whether long or short woolled, having become fixed on, it will be found best to adhere thereto, and not to cross with a view to the division of properties. Thus, an attempt to produce a mixture of the long and short woolled breeds, might in all probability disappoint expectation, and not be useful for either combing or carding. Length of staple in the long woolled breed, and fineness, elasticity, and closeness in the short-woolled fleece, will be the best guides in this case.

In all cases the carcass of the animal ought to be amply and regularly covered; it is a great defect when the belly is bare, as is too often the case with the American sheep, and a still greater when the wool is thin and open along the ridge of the back, admitting rain, which washes out the yoke or natural grease and chills the animal. At shearing time, notice should be taken of the fleece when cut off, and if it be stichy-haired at the bottom or part of separation, it should be marked for fattening. In the formation of a stock, such

sheep should be avoided. In a general way, those should be chosen for breeders that have the finest, closest pile or thickest fleece, and have the greatest uniformity in the texture of the whole fleece, and are in the best condition at the time, provided the pasture has been nearly equal.

In various parts of the United States, sheep of good forms and valuable fleeces are to be seen; but few persons have attended to the preservation of their stock, with that care which a measure so important deserved. Within a short time however the eyes of the public have been opened, and it is to be hoped that the debasement of a valuable stock by the neglect and unrestrained intercourse with inferior rams, will be no longer permitted. Those anxious to improve should make it a point to preserve the best formed and most thriving of their lambs for breeders, whether ewes or rams, and carefully put away, or fatten all those of inferior forms or of less thrifty dispositions.

Of imported sheep we have four kinds, and all valuable. viz. Spanish or Merino, Broad-tailed or Tunis, Irish, snd New Leicester breeds, on each of which a few remarks shall be made.

The Spanish or Merino sheep are universally known for the superior fine quality of the wool, and it is agreeable to know that so far from degenerating in this country, the improvement in fleece is evident in proportion to the increase of blood.—It is a fact, that upon some occasions, the very first cross between the Spaniard and American ewes gives lambs, which in the course of even the first year attain to a greater size than the sire:—that the mutton is excellent; that the crosses fatten in much less time than the common sheep of the country:—that they are very hardy, healthy, and do not become sick when fat, nor are they affected by the pelt rot, like our native sheep in winter, if kept in good heart, (as they always should be); nor do they shed their wool in the spring; that their bodies are completely covered, and lastly, that the ewes make excellent nurses.

It may be necessary to repeat to the American improver, that no judgment can be formed with respect to the ultimate quality of the wool or forms of this breed from the appearance of the lambs, until they are upwards of a year old; and for this reason, no males of the higher bloods should be sold, until the second year, unless they are defective in form.

The facts stated with respect to the importance of the female in all attempts to improve form, particularly apply to the case of sheep. One objection to the Merino breed, which frequently has been offered by those who consider size as all important in cattle, is the general diminutive appearance of the full blooded rams. But it should be known, that it is upon the mother we must principally depend for an increase of carcase, and for improvement of form. The sire gives the fleece; a due attention therefore to the size and form of the ewes in the formation of a flock, is of the first consequence to insure success. These principles, hitherto but little known in this country, will probably admit of controversy, or excite doubts, but their accuracy has been repeatedly demonstrated by the experience of numerous intelligent breeders, and by all those European improvers who have favoured the public with the result of their experiments and observations.

The idle notion, that Merino sheep can produce fine wool only in Spain, has been amply disproved by Lasteyrie, and by the result of the experience of the English and American improvers.

In France, owing to the care taken to provide plenty of food at all times; to the selection of the largest and best formed and finest woolled ewes and rams for breeders, and to not using either until the second year, the flock of the national farm has been brought to carry finer and heavier fleeces, and to be better formed than any in Spain. The long journies which the Merino breed in Spain are obliged to take, to procure food every day, owing to the numbers kept together, and which are absurdly supposed to contribute to the preservation of the fine quality of the wool, tends on the contrary to diminish their size, and injure the wool; for instead of laying down to chew their cud, after they have filled their stomach, they are forced to march several miles, and by this forcible deviation from the laws of nature, their digestion is impeded, and nutrition, and consequent growth, is proportionably defective.

The Merino race affords a variety of advantages over every other kind of sheep, and ought therefore, under the present circumstances of the country, to demand the first attention from our farmers. Mr. Livingston has remarked, and with great truth, that wool, in the United States, is more valuable, and is certainly more scarce than meat; while the contrary is the case in Europe, and particularly in England. Merino wool sells from 75 cts. to 2 dolls. per lb.; and from the increasing number of manufactories in the United States, will for many years command those prices; for the consumption of fine

cloth will increase in proportion to the readiness with which it can be obtained. But the fact is, as already stated, that this breed, having a fair chance, yields good mutton, as well as good wool.

The Barbary breed of sheep with broad tails carry good and long wool, and fatten easily and to desirable weights.

The Irish breed is confined principally to the vicinity of West Chester in this state: they fatten to great weights at three years old.

The possession of the new Leicester sheep may be justly deemed a treasure to the United States; where, from great inattention, most of the breeds formerly among us have become worn out, so that they are difficult to fatten, and have degenerated in form.

We owe the introduction of this valuable breed to the spirit and exertion of ——, Beans, now of New Jersey, who succeeded in shipping some rams and ewes from England, a few years since; the full-blood descendants of which are exclusively in the possession of captain Farmer of New Brunswick, New Jersey. But their progeny is distributed throughout the state of New Jersey, and a part of Pennsylvania.

The barrel shape of the bodies of the New Leicesters, their very gentle disposition, and natural indolence, cause them to take on fat very speedily, and hence answer admirably to cross with the narrow backed, flat sided, long legged breeds. The objection to the full breed in England is the same that is made to all the stock of Bakewell; namely, a too great tendency to take on external fat without a due proportion of lean. This objection will not apply to the cross with most of the American sheep, in which all addition of fat may be considered as clear gain. The object to be aimed at by the assistance of the new Leicester sheep, is the origination of a breed by crossing with our native stock, which will increase the tendency to speedy fattening, without diminishing the due proportion of flesh, so desirable in all stock; and to this object we beg leave to direct the attention of the American improver.

Swine.—A great diversity of breeds of Swine are found in all parts of the United States, some of which are highly valuable, and others very worthless. Several persons within my knowledge have hogs which at 15 and 18 months old, will weigh 300lbs. and upwards. Of the foreign breeds near Philadelphia, only two are distinctly and accurately marked, viz. the African and Chinese. The first is most commonly white, of good shape, wide behind, small pointed ears, and a pouch on each jowl. They will fatten with less food than almost any other breed; have very thin skins, and very small bones: at four weeks old will weigh ten and a half lbs.; hence they take the lead as roasters in our markets. "At 18 months they will weigh from 150 lbs. to 250lbs. but are ripe with good keeping at 12 months. The objection to them is, that they incline too much to fat, and throw it on the outside, and do not marble the flesh, and hence are most fit for the labouring class. When deep in the blood, they become so fat, merely by grazing and having the common slops of a farm, as to diminish their disposition to procreation. For these reasons, a cross with some of the common breeds forms an evident improvement, for more flesh is thus acquired, than is possessed by the African, while the superior tendency of the latter speedily to take on fat, is what our common breeds are lamentably deficient in. The Chinese hogs are invariably black, fatten easily, are smaller than the African, are very prolific, have thick skins, hollow backs and pendant bellies, almost touching the ground; their tails are curled and in perpetual motion. It is extremely desirable to originate a breed which shall partake of the disposition to fatten speedily, and at the same time will diffuse the fat through the flesh.

I shall conclude the subject of the improvement of the breed of cattle, by the following observations of sir John Saunders Sebright, Bart. M. P. contained in a small pamphlet, recently published.

" Were I to define what is called the art of breeding, I should say, that it consisted in the selection of males and females, intended to breed together, in reference to each other's merits and defects.

It is not always by putting the best male to the best female, that the best produce will be obtained; for should they both have a tendency to the same defect, although in ever so slight a degree, it will in general preponderate so much in the produce, as to render it of little value.

A breed of animals may be said to be improved, when any desired quality has been increased by art, beyond what that quality was in the same breed, in a state of nature: the swiftness of the race-horse, the propensity to fatten in cattle, and the fine wool in sheep, are improvements which have been made in particular varieties of the species to which these animals belong. What has been produced by art, must be continued by the same

means; for the most improved breeds will soon return to a state of nature, or perhaps defects will arise, which did not exist when the breed was in its natural state, unless the greatest attention is paid to the selection of the individuals who are to breed together.

We must observe the smallest tendency to imperfection in our stock, the moment it appears, so as to be able to counteract it, before it becomes a defect; as a rope dancer, to preserve his equilibrium, must collect the ballance, before it is gone too far, and then not by such a motion as will incline it too much to the opposite side

The breeder's success will depend entirely upon the degree in which he may happen to possess this particular talent.

Regard should not only be paid to the qualities apparent in animals, selected for breeding, but to those which have prevailed in the race from which they are descended, as they will always show themselves, sooner or later, in the progeny: it is for this reason that we should not breed from an animal, however excellent, unless we can ascertain it to be what is called *well bred;* that is, descended from a race of ancestors, who have, through several generations, possessed, in a high degree, the properties which it is our object to obtain.

The offspring of some animals is very unlike themselves; it is, therefore, a good precaution, to try the young males with a few females, the quality of whose produce has been already ascertained: by this means we shall know the sort of stock they get, and the description of females to which they are the best adapted.

If a breed cannot be improved, or even continued in the degree of perfection at which it has already arrived, but by breeding from individuals, so selected as to correct each other's defects, and by a judicious combination of their different properties, (a position, I believe, that will not be denied,) it follows that animals must degenerate, by being long bred from the same family, without the intermixture of any other blood, or from being what is technically called, *bred in and-in.*

I do not believe, that there ever did exist an animal without some defect, in constitution, in form, or in some other essential quality; a tendency, at least, to the same imperfection, generally prevails in different degrees in the same family. By breeding *in and-in,* this defect, however small it may be at first, will increase in every succeeding generation; and will, at last, predominate to such a degree, as to render the breed of little value. Indeed, I have no doubt but by this practice being continued, animals would, in course of time, degenerate to such a degree, as to become incapable of breeding at all.

The effect of breeding *in and-in* may be accelerated, or retarded by selection, particularly in those animals who produce many young ones at a time. There may be families so nearly perfect, as to go through several generations, without sustaining much injury, from having been bred *in and-in*; but a good judge would, upon examination, point out by what they must ultimately fail, as a mechanic would discover the weakest part of a machine, before it gave way.

Breeding *in and-in,* will, of course, have the same effect in strengthening the good, as the bad properties, and may be beneficial, if not carried too far, particularly in fixing any variety which may be thought valuable.

By selecting animals for one property only, the same effect will, in some degree, be produced, as by breeding *in-and-in:* we shall obtain animals, with the desired property in great perfection, but so deficient, in other respects, as to be upon the whole an unprofitable stock.

We should, therefore, endeavour to obtain all the properties that are essential to the animals we breed. The Leicestershire sheep prove that too much may be sacrificed, even to that most desirable quality in grazing stock; a disposition to get fat at an early age, and with a small quantity of food.

Many causes combine to prevent animals, in a state of nature, from degenerating; they are perpetually intermixing, and therefore do not feel the bad effects of breeding *in-and-in:* the perfections of some correct the imperfections of the others, and they go on without any material alteration, except what arises from the effects of food and climate.

The greatest number of females will, of course, fall to the share of the most vigorous males; and the strongest individuals of both sexes, by driving away the weakest, will enjoy the best food, and the most favourable situations, for themselves and for their offspring.

A severe winter, or a scarcity of food, by destroying the weak and the unhealthy, has all the good effects of the most skilful selection. In cold and barren countries no animals can live to the age of maturity, but those who have strong constitutions; the weak and unhealthy do not live to propagate their infirmities, as is too often the case with our domestic animals. To this I attribute the peculiar hardiness of the horses, cattle, and sheep,

bred in mountainous countries, more than to their having been inured to the severity of the climate; for our domestic animals do not become more hardy by being exposed, when young, to cold and hunger: animals so treated will not, when arrived at the age of maturity, endure so much hardship as those who have been better kept in their infant state.

Although I believe the occasional intermixture of different families to be necessary, I do not, by any means, approve of mixing two distinct breeds, with the view of uniting the valuable properties of both: this experiment has been frequently tried by others, as well as by myself, but has, I believe, never succeeded. The first cross frequently produces a tolerable animal, but it is a breed that cannot be continued.

The introduction of Merino sheep to this country opens a fine field for improvement: it has been ascertained, that neither the sheep nor the wool sustain any injury from the change of climate or pasture; and the absurd prejudice, that Merino wool could be grown only in Spain, is fortunately eradicated.

It is well known, that a particular formation generally indicates a disposition to get fat, in all sorts of animals: but this rule is not universal, for we sometimes see animals of the most approved forms, who are *slow feeders*, and whose flesh is of a bad quality, which the graziers easily ascertain by the *touch*. The disposition to get fat is more generally found in some breeds than in others.

I have always found the fineness of the fleece in exact proportion to the quantity of yolk it contained. Those who are unaccustomed to examine wool, may consider this as a certain criterion of its quality: for although the hair of some dry fleeces may be fine, it will always want the elasticity which is so much valued by the manufacturer.

It is to be regretted, that so little attention has been paid to the improvement of British wool, and particularly to that of the short-woolled breeds; a fine fleece is not only more profitable to the owner, but from the closeness of its texture, and the quantity of yolk it always contains, is a much better protection to the sheep in bad weather, than the open and hairy covering, which too generally disgrace our flocks.

The fineness of the fleece, like every other property in animals of all kinds, may be improved by selection in breeding. The opinion that good wool could only be produced in particular districts, is a prejudice which fortunately no longer exists.

Climate, food, and soil, have certainly some effect upon the quality of wool, but not so much as is generally supposed. The fleece is affected by the degree of nourishment which the animal receives, not by the quality of the pasture on which it is fed. If sheep are highly kept, the wool will be less fine, but in other respects its flesh will not be deteriorated. The wool of a starved sheep may be apparently fine, but it will be brittle, and of little value to the manufacturer.

A regular supply of food to the sheep is essential to the growth of good wool, for that part of the hair which grows when the animal is in a high state of flesh, will be thick, and that which is grown when it is reduced by hunger, will be weak and thin; and consequently the thickness of hair will always be irregular, if the animal passes from one extreme to the other.

The alteration which may be made in any breed of animals by selection, can hardly be conceived by those who have not paid some attention to this subject; they attribute every improvement to a cross, when it is merely the effect of judicious selection.

Upon the contested point of the size of cattle, it may be proper to say something on the present occasion. Even keeping the grand object of all farmers and graziers, in view, viz. profit, the only consideration would seem to be, what variety of any particular breed of cattle will soonest make the most profit, or return of flesh or fleece from a given quantity of food. It follows therefore clearly, that if the same quantity of food be placed on one animal or on three, in a given time the profit to the farmer is the same. In the case of sheep, the superior value of the fleece may even more than compensate for a deficiency of flesh, were that an object of prime attention, but it is a fact, as has been more than once stated, that even in respect to flesh the Merino breed is inferior to none. Without detailing the arguments which might be urged on both sides of the question, we may say generally, that the result of several experiments made in direct reference to the point, was in favour of the superior profit of smaller animals. Much more however will certainly depend upon the disposition of the animal to take on fat, than upon his size, and hence the great importance of attending to the improvement of form is made manifest. In the case of sheep, it will be seen, by the communication in this number, that those of a small size are more profitable feeders than the larger species. Both large and small cattle however are necessary; the former for long voyages, the latter for home consumption, and the

judicious farmer will always of course suit his stock to his pasture, or to the particular situation or circumstances in which he may be placed. Thus on upland, if the farmer feeds on clover and has not the excellent green grass, or spear grass as it is sometimes called, (*Poa Viridis*) it is a folly to attempt to feed cattle above 6 or 700 Cwt. for the frost will destroy his grass, and then corn, potatoes and hay must be resorted to. In the luxuriant meadows on Delaware and Schuylkill, owing to the abundance of that most excellent natural production of the United States, just mentioned, cattle will continue to thrive a full month after frost, and then, if destined for long voyages, corn meal for a short time will pay well; but as usually given, a loss will inevitably be sustained.

Breeding *of Fish*. The necessary qualities of a pond for breeding fish are very different from those which are requisite to make it serve for their nourishment. A good breeding pond is more rarely to be met with than a good feeding one. The best indications of the former are plenty of rushes and grass about its sides, with gravelly shoals, like those of horse-ponds. The quantity of the spawn of fish is prodigious; and where it succeeds, one fish may sometimes produce millions. Hence two or three melters, and as many spawners, placed in such a pond, will, in a short time, stock a whole country. If it be not intended to keep these ponds entirely for breeding, but to let the fish grow to a considerable size, their numbers should be thinned, or they will otherwise starve each other. Different kinds of fish may also be added, which will prey upon the young, and prevent their increasing in number. For this purpose, eels and perch are most useful, because they not only feed upon the spawn itself, but also upon the young fry. Some fish will breed abundantly in all kinds of waters; of this nature are the roach, pike, perch, &c.

BREWING. The art of preparing beer or ale from malt, by extracting all its fermentable parts in the best manner; by adding hops in such proportions as experience has shewn will preserve and meliorate the extracts; and by causing a perfect fermentation in them, by means of yeast and barm. One of the most approved methods of performing this operation, is as follows:

Take of the purest and softest water you can procure, as much as you will have occasion for; boil it, put it into large tubs, and let it stand exposed to the air to purge itself, at least one week. Grind a sufficient quantity of the best brown, high-dried malt; let it remain four days before you use it, that it may mellow, and dispose itself for fermentation. Fill a copper with your prepared water, and let it boil; then lade about three-quarters of a hogshead into the mash-tub, filling the copper up again, and making it boil. When the water in the mash-tub is cooled to such a degree, that in consequence of the steam subsiding, you may *see your face in it*, empty into it, by degrees, nine bushels of the malt, mash it well, and stir it about with the rudder near half an hour, till it is thoroughly wetted, and incorporated with the water: then spread another bushel of malt lightly over its surface, cover the whole with empty sacks to keep in the steam, and leave it for an hour.

At the end of the hour, the water in the copper being boiling, damp the fire, and let the water cool a little as before: then lade as much as is necessary on the mash, till the whole together will yield a bout a hogshead of wort. When this second quantity of water is added, stir it again well, cover it, and leave it for another hour. Then let the first wort run in a small stream into the under back, and lade another hogshead [or 64 gallons] on the mash: stir it again as before, cover it, and let it remain for two hours.

In the mean time, return the first wort into the copper, and put into it six pounds of fine brown seedy hops, first rubbing them between the hands. Then make a brisk fire under your copper, till the liquor boils; let it continue to boil till the hops sink: [the sinking of the hops is not always a sign of the liquor being boiled enough. A better method is when the wort bucks well and is perfectly clear. The casks must be filled up every three hours. A. A.] Then damp the fire and strain the liquor into coolers. When it is about as warm as new milk, mix some yeast or barm with it, and leave it to work till the surface appears in curls; then stir and mix the whole properly with a hand-bowl, and let it again ferment. Repeat the stirring with the bowl three times, then tun it, and leave it to work in the hogshead. When it has nearly done working, fill up the cask, and bung it, but let the vent-hole remain open.

Set the second wort aside for the next brewing, which, as far as wetting the mash, must be managed exactly in the same manner as the first; but afterwards, instead of water, heat the second wort of the first brewing, and lade it on the mash, which will give the new wort additional strength and softness. Make the second wort of the second brewing with water, and save it for the first wort of the third;

and so on for as many brewings as you please. A third wort may be taken from the first brewing, which should be heated and laded on the mash of your second brewing, after taking off the second wort; and thus an additional hogshead of very good mild beer may be procured.

On taking a review of the above process, and the multiplicity of circumstances to be attended to, it is easy to see that the operation of brewing is of a very precarious nature; and requires great skill and dexterity to manage it with complete success. The goodness of the beer will depend on the quality of the malt from which it is made; on the peculiar properties of the water with which it is infused; on the degree of heat applied in the mashing; on the length of time the fusion is continued; on the due manner of boiling the wort, together with the quantity and quality of the hops employed: and on the proper degree of fermentation: to ascertain all which particulars, with precision, constitutes the great mystery of brewing, and can only be learnt by experience and repeated observation.

Mr. Mills, in his *System of Practical Husbandry*, and Mr. Combrune, in his *Theory and Practice of Brewing*, give the following directions for the choice of materials used in brewing, and for conducting the whole process:

1. *Of the Water.*—Pure rain-water, as being the lightest, is esteemed the most proper. Well and spring waters are commonly hard, and consequently unfit for drawing the tincture completely from any vegetable. River-water, in point of softness, is next to rain-water: and even pond-water, if pure, is equal to any other for brewing.

2. *Of Malt.*—Those malts are to be preferred for brewing, which have been properly wetted and germinated, then dried by a moderate heat, till all the adventitious moisture is evaporated, without being blown, vitrified, or scorched, by too hot or hasty fires. For, the better the malt is dryed, the sounder will be the beer brewed from it, and the longer it will keep. In order to ascertain the quality of this article, bite a grain of it asunder, and if it tastes mellow and sweet, breaks soft, and is full of flour from one end to the other, it is good; which may also be known by its swimming on the surface, when put into the water. The best way of grinding it, is to bruise it in a mill composed of two iron cylinders. These break the malt without cutting its husk, so that the hot water instantly pierces its whole substance, and soon draws forth a rich tincture, with much less mashing than in the common way.

3. *Of Hops.*—Experience has proved, that hops slack-dried, or kept in a damp place, are pernicious ingredients for making beer; and likewise, that they yield their aromatic bitter more efficaciously, when boiled in wort than in water; hence, to impregnate the extracts from malt with a due proportion of hops, their strength, as well as that of the extract, should previously be ascertained. The newer the hops are, the better they always prove; the fragrance of their flavour being in some degree lost by keeping, notwithstanding the care used in preserving them. Private families, who regard only the flavour and salubrity of their malt liquors, should use from six to eight bushels of malt to the hogshead of their strongest beer. The quantity of hops must be suited to the taste of the drinker, and to the time the liquor is intended to be kept. From two to three pounds will be sufficient for a hogshead, though some go as far as six pounds. Mr. Mills is of opinion, that *small beer* should always be brewed by itself; in which case, two bushels and a half of malt, and a pound and a half of hops, are sufficient to make a hogshead.

4. *Of the Vessels used in Brewing.*—The brew-house itself, and every vessel in it, ought to be perfectly clean and sweet; for if the vessels are in the least degree tainted, the liquor put into them will contract a disagreeable scent and taste. A vessel of the most simple and excellent contrivance, among the multiplicity of brewing utensils adapted to family purposes, is that of Mr. J. B. Bordley, who has described it in his *Essays and Notes on Husbandry and Rural Affairs*, (Philadelphia, 1801.) He terms his process, by way of distinction, *a tripartite method of brewing*: because the *kettle-apparatus* is worked in *three* divisions. The whole vessel is 40 inches long, 20 broad, and 24 deep: namely, the first or upper division is two, the second is nine, and the third or bottom, thirteen inches deep. The bottoms of the two uppermost are finely perforated and moveable. In the bottom division is the *water* or *wort*; the middle one contains the *malt*; and into the top the hot water is pumped up, or poured over by means of a small pump, and thus passes through every particle of the malt; so that, by frequent agitation, the water in a manner washes out its whole substance, and extracts all its farinaceous and saccharine ingredients. This operation is repeated, occasionally stirring up the grains,

till the liquor becomes clear, when it must be let off into a kettle and boiled with hops, the proper proportion of which must be determined by experiment; it must afterwards be let out into coolers. Mr. Bordley ingenuously acknowledges, that a Swedish method of brewing in camp afforded him the hint for this invention. He also observes, that his tripartite kettle is made of copper, and the small pump of *metal*, and may be either permanently fixed, or past through a cylinder, so as to raise the water from the lower to the upper division; though we are inclined to think that, for the latter, wood, or *pure tin*, would be preferable to brass, in order to prevent the formation of verdigrise. At the bottom is a cock on one side of the vessel. On the whole, we consider this as the most proper and convenient piece of machinery, ever contrived for family-brewing.

5. *Of the heat of the water for Mashing.*—Particular care should be taken, that the malt be not put into the water whilst boiling hot. In order to bring the water to an exact heat, Mr. Combrune advises us, to put on the fire 22 quarts, gallons, or barrels, according to the quantity wanted; and when it has just arrived at the boiling point of the thermometer, to add 10 similar measures of cold water, which, when mixed with the former, will be of a temperature not exceeding 161° of Fahrenheit: and this he considers as the most proper heat for mashing. He farther remarks, that water which has endured the fire the shortest time, provided it be hot enough, will make the strongest extract.

6. *Of Mashing.*—When the water is brought to a due heat, the malt is to be put in very leisurely, and uniformly mixed with it.

7. *Of boiling the Wort*—As the design of boiling the wort is to clear the liquor of its impurities, and to obtain the virtue of the hop, a much shorter time than usual is sufficient. Long boiling of the hop is a most pernicious practice, and produces an austere, nauseous bitter, but not a pleasant aromatic one. Instead of adding the hops to the wort, when this is put into the copper, or before it boils, they may be infused about five minutes before the wort is taken off the fire: if this is not sufficient to give the desired degree of fragrant bitter, ten minutes may be taken, or as much longer as will be found necessary. Mr. Mills prefers putting the hops to the wort towards the latter end of the boiling, rather than at the beginning, because the continued boiling of the liquor is apt to dissipate their fragrance.

8. *Of Fermentation.*—One gallon of yeast, in the coldest fermenting weather, is, according to Mr. Combrune, sufficient to ferment the extract from one quarter of malt; and, if properly managed, will yield two gallons of yeast. Great care should be taken in the choice of yeasts, as they are liable to be soon tainted, and very readily communicate their infection to the liquors fermented. The whole process of fermentation ahould be carried on in the slowest and coolest manner; so that the temperature, which at the commencement was between 40 and 50° of Fahrenheit, should very gradually be raised to the 70th degree. [This is proper for a large quantity; but for small, 66 is the best.] Fermentation will always succeed best where the air is purest. If too hot water has been employed for obtaining strong and fatty extracts, from the malt, fermentation will be retarded: on the contrary, in weak extracts, it is so much accelerated, that the whole soon becomes sour. When the fermentation is at its height, all the feculent matter, or foul yeast, which rises on the surface, must be carefully skimmed off, whatever be the quality of the liquor. The beer, as soon as it is tolerably clear, should be racked off into perfectly clean and sweet casks; and when managed in this manner, will remain a long time in a state of perfection.

9. *Of fining the Liquor.*—As the excellency of all fermented liquors depends, in a great measure, on their transparency, it often becomes necessary to resort to artificial means, in order to bring them to this state of perfection, if the process of fermentation has been mismanaged. Thus, a solution of isinglass in stale beer, is used to fine and precipitate other beers: but, as this method has proved ineffectual in brown beers, we are informed by Dr. Combrune, that brewers "*sometimes put one pound of oil of vitriol* into *one butt*, though four ounces should never be exceeded in that quantity.

10. *Of the distempers of Malt Liquors.*—Among the distempers incident to beer, one, which has been found most difficult to cure, is that of its appearing ropy. A bunch of hyssop put into the cask will, however, effectually remedy this evil.

It deserves to be remarked, that *brown* beer, made from well-dried malt, is, in the opinion of Mr. Combrune, less heating than *pale* beer, brewed from slack-dried malt. If extracts from pale malt be made with very hot water, they will keep sound for a long time; but those obtained from brown malt, with too cold water, will frequently turn sour.

Family brewing, and brewing in small quantities.

An establishment for a moderate family may be thus formed.

A Brew-house 20 feet by 15 on the ground plan. A COPPER with a brass cock at the bottom; to hold not less than 40 gallons, to be set high. A MASH-TUN to hold twice as much as the copper, for the malt will occupy when wetted as much space as the water. The mash-tun should stand a little below the level of the cock of the copper; so that the water of the copper can run into the mash. The mash-tun should have a false bottom on which the malt is placed, this should be bored with ¼ inch holes, at about 3 inches distance; the depth between the solid bottom and the false moveable bottom 6 inches. A cock or plug should be fixed between the two bottoms, to let off the wort into the UNDER-BACK; this should hold as much as the copper.

From the under-back, the wort is pumped up into the copper, to be boiled: when boiled, it is let into the COOLERS: Of these there should be two, each to hold 45 gallons. They should be placed one under the other, and a little below the level of the cock of the copper; that is on a level with the top of the mash tub. The wort, when boiled, is to be let off into the first cooler, and then into the cooler underneath; whence it runs into a working tun of the same size as the mash-tun: for though not more than 32 or 33 gallons of wort runs in at a time, yet the head, produced during the working or fermentation, will occupy a considerable space. The coolers should not be more than 6 inches deep—Thence the establishment of utensils will be.

A copper of 40 gallons, or 45.

A mash-tun of 80 gallons.

An under-back of 40 gallons.

A working tun of 80 gallons.

Two coolers, 6 inches deep to hold each 40 or 45 gallons, 6 ft. by 2 ft. 6 inches each.

A hand pump to pump the wort into the copper, unless it can be done by the water pump.

Pales, Bowls, &c.

A stilling to set the casks on when full about ten inches high, and 14 inches wide in the clear. Four rum puncheons sawed through the middle, would answer tolerably well for almost all the utensils. One bushel of malt and 1lb. of sugar will make one barrel of good table beer, of strength between ale and small beer, if the first and second worts are boiled and mixed together. This, exclusive of trouble, will not cost above one-sixteenth of a dollar a gallon. The Brewhouse should be placed on the north side of the buildings; it should be open on three sides to let in air, and let out steam; the three open sides should have hooks fixed to them, so as to hang on flap-boards, or slanting battens to keep out the wet. But as there are many small families, who cannot afford such an establishment these may brew in small quantities as follows.

Every family has a large kettle or vessel to boil their clothes in; suppose this to contain about 3 gallons, this will serve for a copper. A common pail with a hole bored through the bottom, and set upon a stilling or some other contrivance to raise it, another pail may receive the wort, and may answer for a fermenting tun, and when the beer has worked so as that the head begins to fall, draw it off into a five gallon keg.

Proportions for 5 gallons of ale.

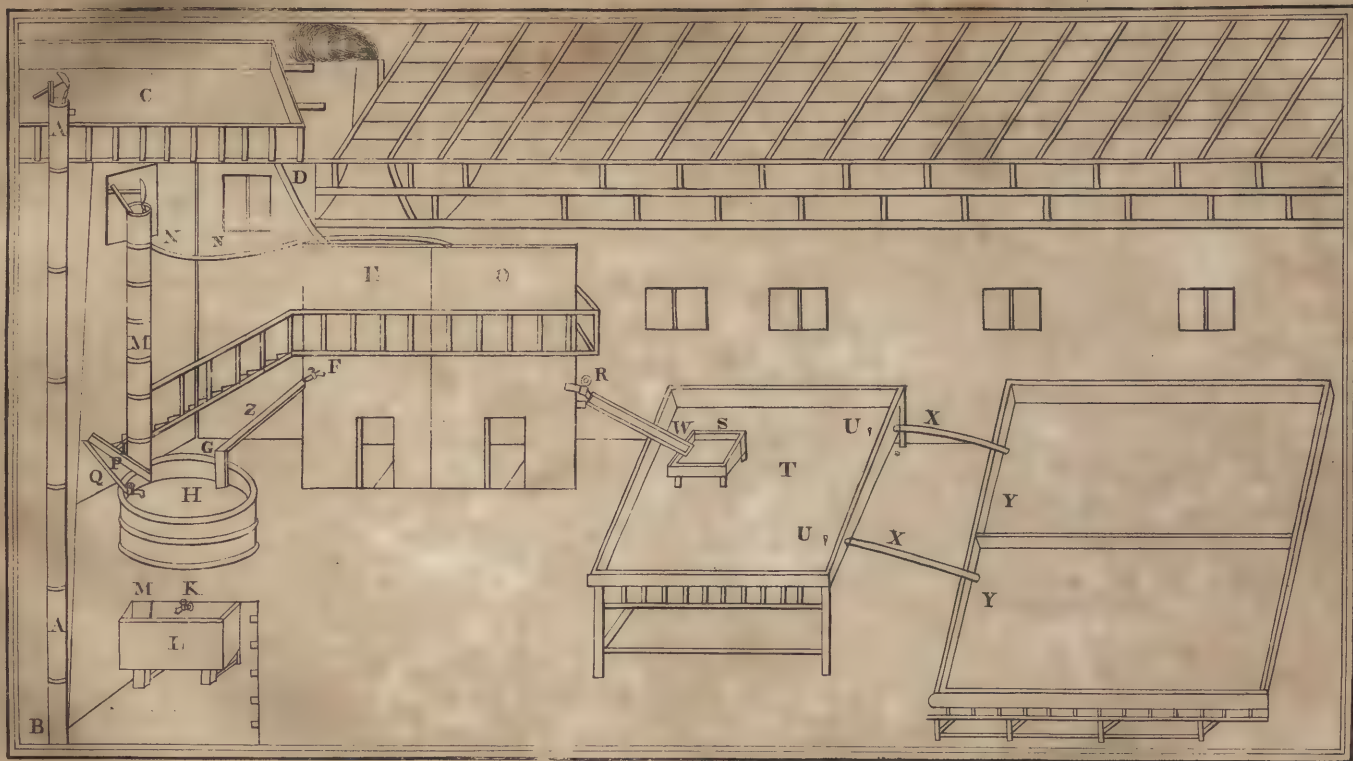
Malt 1½ peck; sugar ½lb. hops ¼ of a lb. malt amber coloured, or pale dried.

Proportions for 5 gallons of porter, brewed in that quantity.

Malt 1½ peck; sugar made into essentia ¼lb. molasses ¼lb. hops ¼lb. ginger about a teaspoonful. The malt to be high dried, or else half amber and half high dried.

These proportions, used according to the foregoing directions, will produce a good wholesome liquor, which the women of the family may brew occasionally when they have not much else to do.

OF THE BREW-HOUSE.—The following is an eligible construction where brewing is followed as a trade. "The cold liquor (Note. Brewers call water whether warm or cold, *liquor.*) pump A.A. raises the water from the river or well B. which, as well as the wort pump M.M. is driven by a horse with proper machinery which likewise grinds the malt used in the brewhouse. The grinding house is situated between the pumps, as may be seen by the mill-spout P. which conducts the malt from the mill into the mash tun H. The liquor from the river B. is pumped into the cistern or reservoir C. where it is ready at all times during the hurry of brewing; and from the cistern it passes through the large pipe D. into the liquor copper E. where it may be stopped by a cock at the extremity of the pipe. The liquor when warmed for mashing is let into the mash-tun H. by opening the cock F. in the bottom of the copper, and runs down the trunk Z. which carries it into the raising spout G. in the mash-tun H. this spout by a notch in the moveable or false bottoms of the mash-tun, conducts the liquor between the moveable and real bottoms, which, by ascending, assists the mashing very much.



View of the inside of a Brewhouse.

"The extract or wort is let go, by turning the cock K. into the underback L. and is from thence carried by the horse-pump M.M. into a level with the wort copper O. and runs from the pump through the pipe N.N. into the wort copper.

"When cold liquor is required for mashing, as is the case in small beer brewing, it is obtained from the cistern C. by the pipe Q. which communicates with it.

"Thus these three very laborious parts of the business, viz. pumping the liquor from the river or well; mashing, and pumping up the worts into the copper, may be easily performed by two men; and they are able to mash a very considerable quantity of malt, and attend to the steaming of the casks, liquoring the backs, &c. between the mashes. When all the worts are in the great copper O. and are boiled sufficiently, they are run off into the first back T. by turning the cock R. the spout W. conducting the worts from the drainer S. which detains the hops. This back communicates with the two large backs Y.Y. which are sufficient to contain all the worts, and they may be laid at a greater or less depth, by using one or both these backs, stopping either of the pipes X. by putting in one of the plugs U.U. The situation of these two backs is higher than the fermenting tuns, and by pipes the worts are conveyed into them below: and if there is conveniency, the tuns, when cleansing, (filling the casks from the fermenting tub,) ought to be high enough to fill the casks in the cellars by means of a leathern pipe."

Of Brewing—Take care that every utensil is made perfectly clean.

Boil your liquor (water); when boiled, reduce it to about the temperature of 175 of Fahrenheit's thermometer. If the malt is newly ground, do not let the water go on, till it is reduced to 165°.

If you have no thermometer, there are three rules which may serve tolerably well.

1st. Let the boiling water be mixed with cold water, till you can perfectly see your face in it; or, 2dly. till it will just scald your finger, unless you take it out immediately. Or,

3dly. Add in winter 1 gallon of cold to 16 of boiling, and in summer 1 gallon of cold to about 12 of boiling water, if you use rain or river water; for of these the temperature varies with that of the atmosphere. If you use well water, 1 gallon to 16 for your first wort throughout the year, will be about enough. Never use rain water, where the washings of the roof give it a bitter taste.

Your first wort will require about twice as much water as the two succeeding; for the malt imbibes and retains about one half of the whole quantity: never let the malt stand dry in the mash-tub. When the water is risen through the holes of the moveable bottom sufficiently, pour in your malt, and let a man stir it about with a rake while you pour it in. When the malt is thoroughly wetted, stir it up with the oars, and raise the malt repeatedly from the bottom, and beat it about: this should be done for a quarter of an hour or 20 minutes. Then sprinkle some dry malt over the top, cover it with a cloth or mat to retain the heat, and let it remain 3 hours in winter, and 2 in summer. Then run it off: pour back the first runnings if they are muddy. A handful of hops put into the vessel in which the wort runs, is advantageous, particularly in summer; preventing the liquor from turning sour.

While this first mash is about, fill your copper again and boil the water for the next mash; which may now be at 185, or 10 degrees hotter: rake and beat this as before and let it stand one hour. For the third mashing, use water at about 190; let it stand one hour: it is convenient to finish mashing by evening, in order to gain the coolness of the night for the wort. When all the wort is extracted, put them together and boil them till you get the quantity you mean to have from the malt. The boiling should be quick and fierce: the hops should be wetted and then broken in among the worts. The worts may boil from an hour to an hour and a half: the copper should have a sloping rim.

The strength of the worts, and of consequence of the liquor, may be ascertained by an hydrometer; a mode first suggested by Richardson, in his treatise on brewing—Thus, if a Florence flask filled with water accurately, up to a mark in the neck, weighs 2 lbs. for instance, the same flask filled with wort properly boiled for ale, and ready to be let off into the cooler, will weigh more. When you have once ascertained the weight of the wort which will make good ale, you may always know in future when your wort is sufficiently boiled; for little evaporates but steam of water impregnated with the oil of the hops. When boiled, turn the worts into the coolers, and the instant they are cool enough, put them to ferment. Otherwise, especially in summer, they are apt to *fox*, as it is called; that is, they acquire a reddish colour and a disagreeable flavour.

They are cool enough at 45 or 50, that is, for a large brewing; but for smaller brewing 60 to 62 degrees will be proper:

and in family brewing 66 to 70, and in very cold weather 76° will be the right temperature. Fahrenheit's scale is alluded to.

In winter, allow one gallon of yeast to the quarter of malt: in summer half a gallon. In winter put in the yeast at once, in summer one half at first, or when the tun is about half full of wort, and the other half when the beer is fit to be cleansed, (that is filled up with wort). When the wort begins to cream, stir it about, and mix the yeast well with the liquor. In winter the beer should be cleansed when the head or froth is just beginning to become solid and thicken. In summer, as soon as it begins to shew a white head.

Generally, when the head becomes brown, solid, and of a yeasty consistence, and seems just ready to fall back into the liquor, the beer should be put into casks. Never suffer the head to break. Better fill the casks a few hours too soon than one hour too late. Strong beer, if brewed in small quantities, and ale in any quantity, should be tunned the second day.

The casks, when well cleaned with hot water, (and if necessary also with lime or ashes to neutralize the acid absorbed by the wood,) should be filled and put upon the stilling, or frame, of about 12 inches high.

Fill up the casks as they work over, once every hour for the first 6 or 8 hours. be sure to keep the casks filled till the fermentation has entirely subsided, which will be in a few days.

Place vessels under the casks to collect the workings over, and the casks may be filled up with the clear part of these workings. Take great care to keep your cellar dry, and free from the drippings of the casks: if the cellar be damp and musty, your beer will be in hazard of smelling.

When the beer has worked in the casks, bung it and remove it, if necessary, to the place where it is to remain: then draw the bung, and fill up with clear beer, scumming off the sediment that may be thrown up by rolling. Bung the casks tight; bore a vent hole, and put in a vent peg, which should be rather slack while the beer is observed to be on the fret. If it runs out at the vent hole, draw off about a quart, to give it room and prevent the starting of the wood.

When beer is drawn, take care never to leave the vent peg out, or loose: the best liquor may soon become flat and vapid by the carelessness of servants in this respect.

Take care also that the sides of the barrels, the stoops and the floor, are not suffered to remain wet with the beer spilled or running over. Dirtiness and moisture are apt to make the beer smell in the barrel.

Of the proportions of Malt and other Ingredients. The following are about the average proportions of malt, used in England: but the barley of America is not equally good, nor is the process of malting carried to such perfection: hence, the same quantity of ale or porter will require about one fourth more of malt to make a liquor in America of equal strength. When nothing is used to make ale or porter, but malt and hops, it will require, in England, about three bushels of malt to make one barrel of ale of 32 gallons, or porter of 36 gallons. But this will be *strong*.

For *ale* intended to be drank immediately, ¾ of a lb. of hops to the bushel, will suffice. If meant to be kept a twelvemonth, allow 1 lb. to the bushel: if longer 1¼ lb.

Porter requires 1½ lb. of hops to the bushel, if no bitter but hops be used.

Small-beer is usually brewed from the malt after the quantity of wort intended for ale is taken off: then a quarter (or 8 bushels) of malt, will make about one barrel of strong ale, and two barrels and an half of good small-beer: the hops used for the ale, kept in a net during boiling, will do with a little addition for the small-beer.

But small-beer so made is never so good as when it is run off by itself from a quantity of malt wholly appropriated to it.

In this case about 1¼ or 1½ bushels of malt will make one barrel of good small-beer, with ¼ of a lb. of hops to the bushel.

But in malt liquor, the addition of a small portion of sugar gives more strength to the liquor, and enables it to keep better; particularly in summer time: hence the following proportions seem preferable in practice, for this country.

Ale—Malt (amber) three bushels: hops 3lbs.; good moist sugar 1½ lb.; about ½ an ounce of coriander seeds will be an improvement. The addition of the sugar will nearly make up for the deficiency in strength of the American malt. This will make one barrel of strong ale.

Having thus afforded an analytical view of this important subject, we shall conclude it with an account of the latest patents, which have been granted to those who have contributed, or attempted to improve the Art of Brewing.

In March, 1788, Mr. W. Ker, of Kerfield, Tweedale, received the king of Great Bri-

tain's patent for his improvement in brewing ale, beer, porter, and other malt liquors, so as to save a considerable portion of hops, to produce the liquors of a superior flavour and quality, and render them less liable to become acid or putrid. The steam which arises from the boiling copper, is known to be strongly impregnated with the essential oil of the hops, in which their flavour consists. Instead, therefore, of allowing it to escape and evaporate, as it does in the common mode of brewing, Mr. Ker contrives to preserve and condense it, by means of a winding-pipe fixed to the copper, similar to the worm of a still, or by a straight pipe passing through cold water, or any other cooling medium. The oil and water, thus obtained, are returned into the worts when boiled; or the oil, after being separated from the water, along with which it has been exhaled, is returned into the worts after they are boiled; and the watery part, which, after the oil is separated, still continues impregnated with the aromatic taste and bitter of the hop, is returned into the next copper or boiling vessel, and so on, from one copper or boiling vessel into another. By this process, a considerable part of the hop and flavour, which is lost in the ordinary mode of brewing, is preserved; the flavour of the liquor is improved by the preservation of the finer parts of the aromatic oil; and the ale and beer are better secured from any tendency to acidity or putrefaction, and therefore must be fitter for home consumption and exportation.

In June, 1790, Mr. John Long, of Ireland, obtained a patent for an improvement which he calls *an entire new method*, in *all the essential parts*, of brewing good malt liquor. Though this method, in one respect, is similar to that adopted by Mr. Ker, yet as it comprehends the whole process of brewing, we shall lay it before our readers, nearly in the words of its author.

1. For the better extracting the virtues of malt, place near a mash-tun a shallow copper, or other vessel, that will readily heat, the curb of which to be on a level with the tun, and to contain from two to six hogsheads, according to the dimension of the tun, more or less; and, at the lower end of the copper, have a cock, from two to five inches in diameter, to conduct the heated liquor from the copper into a tube, which passes down the external part of the tun, and enters it through an aperture about six inches from the bottom; then forming two revolutions, more or less, through the body of the tun, and communicating its heat to the wort as it passes through the tube; and then, at a convenient distance from the place where it first entered, it runs from the tun into a cistern or tub, situate as near as convenient to the copper or heating-vessel. In the tub or cistern is to be placed a pump, for the purpose of conveying the cooler liquor back to the copper or heating vessel again, there to receive the heat of 208 degrees, more or less, (which it will require after the first half hour,) and then convey it through the mashing-tun, as before, and in the same manner, as long as the working brewer may think necessary, to raise the mashing-tun to any degree of heat required. By adhering to the foregoing process, the first liquor may, with the greatest safety, be let upon the malt, from 20 to 30 degrees lower than the present practice; by which means it operates with gentleness, opens and expands the malt, and prepares it for the reception of sharper or warmer liquor, so as to extract the whole of the saccharine quality from the malt. By the foregoing method, the mashing-tun, instead of losing its first heat, (which it does by the present practice,) continues to increase in heat every moment by conveying the heated liquor through the tube into the tun; by which means, at the end of two hours, the working brewer can have the tun brought to any degree of heat he shall think best suited to the different qualities of the malt. Persons who would wish to save expense, may heat their mashing-tun at the side or bottom, by a large piece of metallic substance made fire-proof, and fixed therein; which, in some degree, will answer the end proposed, but with great trouble and delay.

2. To prevent the wort from receiving a disagreeable flavour, while in the under-back, a tube must be placed at the cock of the mashing-tun, to receive the wort as it comes off, and convey it to a great cistern, or refrigeratory, which is supplied with a stream of water. The wort, passing through that medium in a spiral tube, soon loses that heat which so often proves prejudicial to the brewer in warm weather; it is then poured from the tube into a vessel in which pumps are placed, to return the worts into the copper, for the purpose of boiling off.

3. As the great object of long boiling the wort is remedied, by this invention of taking the extract from the hops in a separate manner from the worts, Mr. Long boils the latter no longer than from fifteen to twenty minutes; and, by pursuing that method, he saves much time and fuel, and regulates the length of time accordingly.

4. He steeps his hops, the preceding day to which they are to be used, in a copper or other vessel, with as much fluid, blood-warm, as will cover the hops; where it is to remain over a slow fire, at least fourteen hours, close covered; the copper, at the tenth hour, not to be of a greater heat than 175 degrees, continuing slow until the last hour. Then he brings the copper gradually to a simmer, or slow boil; in which state he suffers it to remain about ten minutes, and then runs off the fluid; and this he does at the same time the first wort is boiled off, that they may both pass together through the refrigeratory, into the fermentation or working-tun. After the foregoing operation, he covers the hops again with other liquor, brings the copper to boil as soon as convenient, and lets it remain in that state a considerable time, until the second worts are boiled off. Then he passes the hop-fluid with the wort, the same as in the first instance; and, if there is a third wort, he boils the hops a third time with small worts, and drains off the liquid as before; by which means, he gradually obtains the whole of the essential oil and pleasant bitter from the hops, which is effectually preserved in the beer.

5. When the wort is boiled off, it is conducted from the cock of the copper or boiler into a tube of a proper dimension, which passes the wort from the cock to the large cistern or refrigeratory, and there performs several revolutions, in a spiral manner, through the same tube; which is immersed in a constant supply of cold water, where it loses the greatest part of its heat in a short time, and thence continues a straight course through the tube, a little elevated, and of a suitable length, placed in brick-work, until it meets a small refrigeratory, supplied with colder water from a reservoir made for that purpose, at the head of the works; whence a continual stream runs on the surface of the tube down to the great refrigeratory, cooling the wort as it passes, in order to enable the working brewer to send it into the backs, or working-tuns, at whatever degree of heat he may think proper. The tubes may be made of lead, or any other metallic substance.

6. To enable him to brew in the warm summer months, Mr. Long sinks the backs, or working-tuns, at least to a level with the ground, but if deeper, the better, and covers them closely by an arch made of bricks, or other materials, that will totally exclude the atmospheric air. He then places them as near as possible to a spring or sand-drain, as their depth will naturally draw the water thence, which must be so contrived as to pass or flow round the backs or tuns. Next, he introduces a large tube, which passes through the tuns, and keeps the wort several degrees lower than can possibly be done by the present practice; by which means he produces a complete fermentation, even in the dog-days.

7. In cold or frosty weather, if the tun and backs should lose the first heat, intended to be conducted through the process by the foregoing method, a supply of warm or boiling water may be conveyed by the tube which passes through the body of the backs or tun, communicating its heat, which rises to any degree the working brewer shall think proper: by pursuing this method, in the coldest season, a fermentation may always be procured.

In February 1798, Dr. Richard Shannon obtained a patent for his method of improving the processes of brewing, distilling, boiling, evaporating, raising, applying and condensing steam or vapour from aqueous, spirituous, saccharine, saline, and other fluids. The principle of his invention consists chiefly in the following arrangement: By covering and making the mash-tun air-tight, and casing it round, under and over, with a steam-tight casing, so that, during the mashing and soaking of the malt and grain used, the heat may be preserved, or raised and regulated to any pitch, by the application of steam, both in and between the casing of the mash-tun; by which contrivance, the whole of the *farina* and substance of the grain may be as effectually extracted in one, or at most in two mashings, as is now done in three or four. The steam, conducted by a proper tube or pipe, is to be also employed for sweetening and cleansing all the brewing, distilling, and vinegar-making utensils, and casks employed in each, &c. so as in future to prevent furring, foxing, &c. even in the inmost crevices.

In June 1798, the same patentee, in partnership with Mr. Robert Burnett, of Vauxhall, procured another patent, for the discovery of a principle and invention of a method of improving the process of fermentation, by which porter, beer, ale, malt and molasses wash, wine, cyder, and all other saccharine and fermentable fluids, may be conducted with certainty through the vinous process of fermentation in mild, warm, hot, and cold weather, without being materially injured as heretofore, by the different changes of the atmosphere, &c. But as these improvements depend on the application of an expensive *pneumatic apparatus*, which does

not appear to us adapted to the use of families, we refer the reader to the tenth and fourteenth volumes of the *Repertory of Arts and Manufactures,* where he will find a detailed specification of both patents.

The last patent we shall mention, is that of Mr. Thornton, of East Smithfield; which, being dated April 15, 1778, is earlier than either of the preceding, and does not strictly relate to the process of brewing, as his invention consists in a new method of reducing *malt* and *hops* to an essence or *extract,* from which beer may be made either at sea or in distant countries. The whole is managed by the transmitted heat of compressed vapour of boiling water, and a proper apparatus for that purpose. This apparatus may be made of iron, tin, or copper: it consists of a boiler of any dimensions, a double vessel, and conducting tubes. The double vessel consists of one vessel placed within another, and fitted tight at their rims. The upper vessel forms the upper part of the under vessel, and contains the liquor to be evaporated. The under vessel is every where inclosed, except at an aperture communicating with the boiler, and at another aperture communicating with the conducting tubes; and is constructed so as not to allow any part of the vapour condensed into drops within it to escape, except back again into the boiler: it is not so extensive as to act as a common refrigeratory, and yet is capacious enough to prevent the liquor boiling over. The aperture communicating with the boiler, is large enough to freely admit the vapour from the boiler into the under vessel; and the aperture communicating with the conducting tubes, is of a proper size to allow of the vapour in the under vessel being compressed, to a degree capable of transmitting to the liquor to be evaporated a proper heat, and at the same time to serve as a passage for more heat than is necessary to keep up that degree of compression. The conducting tubes are to convey this superfluous heat or vapour, to be used for farther purposes, or immediately out of the building.

Those of our readers who are desirous of farther information on the subject, may consult the last edition of *Philosophical Principles of Brewing,* by Mr. Richardson, of Hull, England; a work of acknowledged merit, and practical utility.

BRICK. Among the numerous branches of the general art of fashioning argillaceous earths into useful forms, and afterwards hardening them by fire, the art of making bricks and tiles is by no means one of the least useful. By this art we possess the advantage of obtaining the materials for constructing edifices at cheap rates, in almost every situation, without the expense of carrying stone from remote quarries; and this is so far from being the only advantage, that it is extremely probable, that these artificial compositions, if properly made, would prove superior in durability to every natural stone. The streets in Holland are every where paved with a hard kind of brick, known by us under the name of clinkers, and used in this country for paving stables and court-yards; and the houses in Amsterdam appear to be not at all decayed, but are perfectly fresh, as if new, though most of those in the vicinity of the Exchange have stood at least two centuries. The spirit of improvement may perhaps effect at some future period in this country, what the stimulus of necessity has done on that naturally poor spot.

The art of brickmaking has for the most part been confined to the manufactories, no one having attended to it in a direct chemical way, except the celebrated Bergman. We shall therefore in the present article give an account of the leading facts and observations in his treatise.

The pottery made use of in the construction of edifices may be considered as of two forms; tiles for the roof, and bricks for the walls; to which may be added another kind of bricks for pavements. Softness and porosity are the greatest fault of tiles. The water retained in the pores of tiles becomes frozen in winter; and as ice occupies a larger space than water, the expansion of the water, at the instant of its congelation, does not fail to split and destroy such porous and brittle substances as tiles which are ill made. This has been remedied by covering them with a glaze, which adds considerably to the expense. Bergman is of opinion, that a stronger heat used in the baking would render them so close as to absorb very little moisture.

This illustrious chemist did not find that pure clay, or argillaceous earth, was fusible either alone or when mixed in any proportion with lime, though the addition of the smallest quantity of siliceous earth brought the mass into fusion. Neither was clay fusible with pure quartz alone. Spath fluor renders it fusible; as does likewise feld spar.

Common clay is scarcely ever found in a state approaching to purity on the surface of the earth. It usually contains a

large proportion of siliceous earth. Bergman examined several clays in the neighbourhood of Upsal, and made bricks, which he baked with various degrees of heat, suffered them to cool, immersed them in water for a considerable time, and then exposed them to the open air for three years. They were formed of clay and sand. The hardest were those, into the composition of which a fourth part of sand had entered. Those which had been exposed for the shortest time to the fire were almost totally destroyed, and crumbled down by the action of the air: such as had been more thoroughly burned, suffered less damage; and in those which had been formed of clay alone, and were half vitrified by the heat, no change whatever was produced.

On the whole, he observes, that the proportion of sand to be used to any clay, in making bricks, must be greater, the more such clay is found to contract in burning; but that the best clays are those which need no sand. Bricks should be well burned; but no vitrification is necessary, when they can be rendered hard enough by the mere action of the heat. Where a vitreous crust might be deemed necessary, he recommends the projection of a due quantity of salt into the furnace, which would produce the effect in the same manner as is seen in the fabrication of the English pottery called stoneware.

It is of considerable importance to examine clay before it is made into tiles. This is done in a rough way by the manufacturers; but Bergman advises the following as the most expeditious process: Nitric acid poured upon unburned clay detects the presence of lime, by producing an effervescence. Calcareous clays, or marles, are often the fittest materials for making bricks. In the next place, a lump of clay, of a given weight is to be diffused in water by agitation. The sand will subside, and the clay remain suspended. Other washings of the residue will carry off some clay, and by due management in this way, the sand, or quartzose matter may be had separate. Nitric acid by digestion will take up the lime from a part of the clay, previously weighed, and this may be precipitated by volatile alkali. The clay, the sand, and the lime may thus be well enough ascertained by weight, so as to indicate the quantity of sand or other material requisite to be added in order to form that compound, which, from other experiments, may have been found best adapted to produce good tiles and bricks. An examination with the microscope will show whether the sand contain feld spar, or other stones of known figure.

The brickmakers in the vicinity of London collect the refuse cinders and ashes of the coal fires of that metropolis, and employ women to sift them. The cinders, called breeze, are used as fuel in the burning, and the smaller powder, or black ashes, enter into the composition of the bricks instead of sand. The proper management of the clay is of considerable importance with respect to the quality of the bricks; and various acts have been passed, to prohibit its use when recently dug. The clay is best if dug in the fall of the year, and exposed to the frosts during the winter, turning it over once or oftener during the time. Indeed the more it is turned and worked with the spade the better. When thus mellowed, it may be thrown into shallow pits in the spring, and left to soak in water some days. It is then to be tempered, and wrought into a smooth paste, with as little water as possible. This is usually done by a horsemill. All the stones ought to be picked out; but this is seldom done, except in the finer articles. When the materials are properly mixed and wrought, the bricks are fashioned in wooden moulds; and then piled up in long double rows to the height of four or five feet, the bricks being so arranged as to admit a free access of air between them, and covered at top with straw, to defend them from the rain. When sufficiently dried in this manner, they are commonly built up into large square heaps, called clams, stratified with fuel between the rows, and leaving room for the fire to play between the bricks. Two or more arches likewise, according to the size of the clam, are formed at the bottom, for holding the fuel, and kindling the fires. In this way it is obvious the bricks cannot be uniformly burnt; and to deficiencies in the management of this process, and negligences in tempering and working the materials, we may probably ascribe the bad qualities of too many bricks. A few of the finest kinds of bricks, for particular uses, as well as tiles, are burnt in kilns erected for the purpose, where the fire can be managed with much more regularity.

A kind of bricks called fire-bricks are made near Windsor, which are very hard, heavy, and contain a large proportion of sand. These are chiefly used in the construction of furnaces for steam engines, or other large works, and in lining the ovens of glass-houses, as they will stand any

degree of heat. Indeed they should always be employed where fires of any intensity are required.

English *statute-bricks* ought, when burnt, to be nine inches long, four and a quarter broad, and two and a half thick: they are commonly used for paving cellars, sewers, sinks, hearths, &c. There is, however, a great variety of bricks, in consequence of their different forms, dimensions, uses, and the method of making them.

On comparing the strength and durability of modern bricks with those of the ancients, it is evident that the former are in every respect inferior; and that we are either unacquainted with the exact materials of which those admirable productions of art are composed, as well as with the proper manner of preparing them; or that this useful manufacture has been shamefully neglected, while our masons and brick-makers are little concerned about the quality of their materials, if they can obtain them in a cheap and expeditious manner. Such appears to be the tendency of the patents that have, from time to time, been procured by various *scheming men*, who are generally ignorant of the first principles of chemistry, on which the successful practice of this important branch of the arts chiefly depends.

Whoever is desirous of producing the best and most durable kind of bricks, ought to attend to the following rules:

1. Clay of every description, whether fat or lean, whether more or less mixed with particles of lime, iron, &c. must be dug up after Midsummer, that is, between the beginning of July and latter end of October, before the first frost appears: it should be repeatedly worked with the spade, during the winter, and not formed into bricks till the following spring.

2. The clay, before it is put into pits for soaking, must be broken as small as possible, and allowed to lie at least ten days: every stratum of twelve inches should be covered with water, as in this manner it will be more uniformly softened.

3. Two such pits, at least, will be necessary for every brick-manufactory, so that after having been suffered to remain for five days, the second may be prepared, and thus the manufacture carried on without interruption.

4. The next step is that of treading and tempering the clay, which requires double the labour to what is usually bestowed on it; as the quality of the bricks chiefly depends upon the first preparation. If, in tempering them, too much water be used, they become dry and brittle; but, if duly tempered, they will be smooth, solid, and durable. Such a brick requires nearly as much earth as one and a half made in the common way, when too great a proportion of water is added; in which case the bricks become spongy, light, and full of flaws, partly through neglect in working them properly, and partly by a mixture of ashes and light sandy earth, (as is generally practised in the vicinity of London,) with a view to dispatch and facilitate the work, as well as to save culm or coals in the burning.

5. Bricks made of proper earth, being more solid and ponderous, require a much longer time for drying than those made in the common way; they ought not to be removed to the kiln, till they have become lighter by one-half, and give a hollow sound on collision; because the proper drying of bricks will prevent them from cracking and crumbling in the kiln.

6. Of whatever materials the kiln be constructed, each burning of from 6 to 10,000 bricks, requires that the fire be kept up for 24 hours, and double that time for a number of from 12 to 50,000. The uniform increase of heat deserves great attention; the duration of it should be regulated according to the seasons; and, during the last 24 hours, the fire should be uninterruptedly supported by means of flues; but afterwards the kiln must not be suddenly closed, as there is always some danger either of bursting the flues, or more probably of melting the bricks.

Fire bricks are made in Philadelphia of certain proportions of clay from the banks of the Delaware, a few miles below Bordentown, and the sand found near the lower bridge on the Schuylkill.

Besides their great utility in the construction of furnaces, they ought to be used for lining the backs and sides of fireplaces.

Among the multiplicity of patents lately obtained for the making of bricks, it is somewhat singular, that the inventors confine their lucrative views chiefly to the formation of this useful article, without paying much regard to the materials of which it may be composed. Of this nature are the patents granted to the following individuals:

1. Mr. Edmund Cartwright, of Doncaster, England, for his invention of a new principle, on which bricks, stones, or any other building materials to be substituted for those articles, may be so formed, as to

be applied with peculiar advantage in the erection of walls, and in the construction of arches. (Dated April 14, 1795.) His improvement consists in giving bricks such a shape or form as that, when in work, they shall mutually lock into, or cramp each other. The principle of his invention, he says, will be readily understood, by supposing the two opposite sides of a common brick to have a groove or rabbet down the middle, a little more than half the width of the side of the brick in which it is made; there will then be left a shoulder on each side of the groove, each of which shoulders will be nearly equal to one quarter of the width of the side of the brick, or to one-half of the groove or rabbet. Buildings constructed with bricks on this principle, will require no bond-timber, one universal bond running through, and connecting the whole building together; the walls of which can neither crack nor bulge out, without breaking through the bricks themselves. When bricks of this simple form are used for the construction of arches, the sides of the grooves or rabbets, and the shoulders, should be the radii of the circle, of which the intended arch is to be the segment. In forming an arch, the bricks must be coursed across the centre on which the arch is turned, and a grooved side of the bricks must face the workman. They may be either laid in mortar, or dry, and the interstices afterwards filled, and wedged up, by pouring in lime-putty, plaster of Paris, grouting, or any other convenient material, at the discretion of the workman, or builder. It is obvious, that arches upon this principle, having no lateral pressure, can neither expand at the foot, nor spring at the crown, consequently they will want no abutments, requiring only perpendicular walls to be let into, or to rest upon; and they will want no incumbent weight upon the crown, to prevent their springing up; a circumstance of great importance in many situations, in the construction of bridges. Another advantage attending this mode of arching is, that the centres may be struck immediately; so that the same centre, (which in no case need be many feet wide, whatever may be the breadth of the arch) may be regularly shifted, as the work proceeds. But the greatest and most striking advantage attending this invention is, the absolute security it affords (and at a very reasonable rate) against the possibility of fire; for, from the peculiar properties of this arch, requiring no abutments, it may be laid upon, or let into common walls, no stronger than what are required for timbers, of which it will preclude the necessity, and save the expense. For a more particular account, we refer the reader to the third volume of the *Repertory of Arts and Manufactures*, p. 84, and following, of which he will also find annexed two plates illustrating the subject.

2. A very important discovery has lately been made by Mr. Whitmore Davis, at Castle Comber, in the county of Kilkenny, Ireland. He observed some persons in the vicinity of a colliery, to employ a mortar for the backs of their grates, which in a short time became hard. This substance he found, on examination, to be what miners term *seat-coal*, or that fossil which lies between coal and the rock. It has been submitted to the investigation of Mr Kirwan, who is of opinion, that it will, when mixed in due proportions with clay, produce a kind of bricks, capable of resisting the action of fire, and consequently well calculated for furnaces, or similar structures. Mr. Davis has accordingly employed it with success; and he farther observes, that seat-coal, if properly prepared, will answer every purpose of tarras, for buildings beneath water.

To conclude, we shall only add, that the reasons why the modern bricks are so very inferior to those made by the ancients; which, in their monuments, after having withstood the ravages of time for many centuries, are still in perfect preservation, appear to be principally the following: In the present expensive state of society, the price of manual labour, though far from being adequate to the pressure of the times, is so considerable, that the manufacturer is under a kind of necessity to make choice of those materials which are the cheapest and most easily procured: thus, a mixture of the most improper earths and clay is often employed in the manufacture of bricks, without reflecting that two bodies specifically different in their nature, must necessarily require different degrees of heat in the kiln, in order to produce an uniform hardness, and an intimate combination of parts. On the contrary, the ancients not only selected the very best sort of clay, but combined it with other ingredients well adapted to form the most complete cement, such as coarsely powdered charcoal and old mortar added to the clay. Of this description, likewise, were the bricks which professor Pallas, on his last journey through the southern provinces of Russia, discovered in the stupendous Tartar monuments, and which would scarcely yield to the force of a hammer. Another advantage peculiar to

the bricks and tiles manufactured by our forefathers, arose from their method of burning them uniformly, after being thoroughly dried. There is no doubt, that if all the defects before pointed out, were removed, and modern brick-makers were to pay more attention to their art, by digging the clay at proper seasons, working it better than is done at present, bestowing more care on the burning of them, and particularly by making them much thinner than what is prescribed by the standard form, we might produce bricks of an equal strength and durability to those of our less enlightened, but more provident and industrious, ancestors.

BRICKLAYERS, artisans whose business it is to build with bricks, and to perform brick-work; such as tiling, walling, chimney-work, and paving with bricks and tiles: in country places, they also undertake the masons' and plasterers' business. The London bricklayers were incorporated as a regular company in 1568, consisting of a master, two wardens, 20 assistants, and 78 of the livery.

The art of bricklaying has been analysed in a particular treatise by Moxon; in which he describes the materials, tools, and method of working used by bricklayers. Great care should be taken that bricks be laid joint on joint in the middle of the walls as seldom as may be. If they be laid in winter, let them be kept as dry as possible; if in summer, they ought to be wetted, because they will then unite with the mortar better than if they were quite dry, and render the work much stronger. In large buildings, or where it is too troublesome to dip each brick separately, water may be thrown on every course after they are laid, as was judiciously done, when building the College of Physicians in London, on the suggestion of Dr. Hooke. If bricks are laid in summer, they should be covered, to prevent the mortar from drying too quickly; because thus it will not be cemented so firmly as if it were left to dry more gradually. In winter also they ought to be well covered, to protect them from rain, snow, and frost, which last is the worst enemy to mortar, especially if the work has become wet before the frost happens.

BRICK-WATER, or water impregnated with the contents of bricks, is possessed of properties so peculiarly striking, and at the same time so pernicious in their effects, when used for culinary purposes, that we cannot, in justice to our readers, withhold from them the following curious experiment made by Dr. Percival, and stated in the first volume of his Essays. He steeped two or three pieces of common brick, four days in a bason full of distilled water, which he afterwards decanted off, and examined by various chemical tests. It was not miscible with soap; struck a lively green with syrup of violets; by the fixed alkali, and by a solution of sugar of lead. No change was produced on it by an infusion of tormentil root. Hence the doctor justly concluded, that the *lining of wells with bricks*, a practice very common in many places, is extremely improper, as it cannot fail to render the water hard and unwholesome. Clay generally contains a variety of heterogeneous matters; and coloured loams often participate of bitumen, and the ochre of iron. Sand and lime earth are still more common ingredients in their composition; and the experiments of Mr. Geoffrey and Mr. Pott prove, that the earth of alum also may in considerable quantity be separated from clay. As, therefore, clay is exposed to the open air for a long space of time, before it is moulded into bricks and burnt, this process in many respects resembles that by which the alum stone is prepared. And it is probable, that the white efflorescence, which is frequently observable on the surface of new bricks, is of an aluminous nature: indeed the combinations of the vitriolic acid with the earth of alum, may be sufficiently accounted for, partly from the long exposure of clay to the air, before it is moulded into bricks, and partly from the sulphureous exhalations of the pit-coal used for burning them, together with the suffocating, bituminous vapour, arising from the ignited coal.

The above experiments of Dr. Percival are highly interesting, and deserve the serious attention of city corporations and private persons. The wells of pumps are in generally only *steined*, that is, lined with dry bricks. Two disadvantages arise from this practice. The first, is the bad qualities which it appears are communicated to the water by the bricks; the second, is the inability of these bricks to prevent the filthy contents of drains and privies from soaking through the ground into the wells, to which cause may be fairly attributed the bad taste of the water in many pumps in Philadelphia, which were formerly proverbial for their excellence. Every privy and well, ought to be lined with the valuable cement of *Capt. Hunn.* It is easily made, and, if the work be well done, the cement will last for ever. See CEMENT.

BRINE, or Pickle, is water saturated with saline particles. It is either native,

as the sea-water; or factitious, when formed by a solution of salt in water.

Pickle made according to the common rule, *that it should bear an egg*, may be sufficiently strong to preserve substances intended for early use. A true pickle, however, for preserving meat, fish, and butter, during a long voyage, ought to be boiled down till the salt begins to crystalize, which is discovered by a thin scum on the surface of the liquid while it continues over the fire. The water being then completely saturated with salt, the pickle is perfect.

BROAD-CAST, a term in husbandry, used to denote a particular mode of sowing corn, pulse, turnips, clover, grasses, and most field-plants. When seeds are scattered over the surface of the ground by the hand, they are said to be sown in broad-cast; by which this method is distinguished from drilling, and horse-hoeing, or the new husbandry.

The comparative merit of the drill and broad-cast, has, by several experiments, been determined in favor of the former. One of the most practical details on this subject, was communicated to the *Society for the Encouragement of Arts, Manufactures, and Commerce*, by Mr. Boote, of Atherstone, who, in the year 1789, obtained the gold medal from that patriotic institution, as an acknowledgement of his merit, in ascertaining this interesting point.

Mr. Boote selected a piece of cold clay land of twenty acres, four of which were drilled with four bushels of wheat; and, at the same time, four acres adjoining, of a similar soil, were sown in the broad-cast way, with ten bushels of the same grain.

In the beginning of April, 1788, the drilled wheat was first hoed, and again in the last week of the same month, when the broad-cast was also hoed, with hoes of a proper size for the purpose.

At harvest, the crops were separately reaped and threshed, to ascertain the difference of each produce. That of the four acres drilled was one hundred and nineteen bushels, one gallon, and four pints; and the four acres broad-cast yielded ninety-four bushels, two gallons, and four pints. Hence the difference in favour of the former, was twenty-four bushels, seven gallons, valued at five shillings and six pence a bushel, together with six bushels of seed saved by drilling, which cost seven shillings and four pence half-penny a bushel, amounting in the whole to nine pounds one shilling and three farthings.

In this comparative experiment, a bushel of wheat produced by the broad-cast was nearly equal in weight to a bushel of that obtained from the drill. Mr. Greenway, however, by an experiment made in the year 1787, found that the grain of his drilled crop was superior to that of his broad-cast, not only in quantity but in quality, the former weighing two pounds per bushel more than the latter. But as his broad-cast crop was not hoed, it may be fairly inferred, that it did not arrive at full maturity, either in consequence of the injury done to it by weeds, or for want of the soil being pulverized by the hoe

It must be evident to the agriculturist, that seed deposited from one and a half to three inches deep in the soil, will vegetate sooner, and grow faster, than that sown on the surface, which is seldom buried deeper than from one-quarter of an inch to an inch—at a season, when moisture is particularly requisite for the growth of the plant.

BRONZE, a metallic compound of copper and tin, to which zinc and other substances are sometimes added. It is hard, brittle, sonorous, and specifically heavier than the metals of which it is composed.

M. Tillet, in his memoir concerning the ductility of metals, observes, that in bronze the colour of the copper is totally disguised by that of the tin, even though the proportion of the former be four-fifths to that of the latter. This compound is much more fusible than copper alone, and less liable to be covered with verdigrise.

From the properties here enumerated it appears, that bronze is well calculated for the casting of bells, cannons, statues, and other works exposed to the air and weather.

Bronze-colour, in imitation of the metal, is much used by the colourmen of Paris, who prepare two sorts of it, namely, the red bronze, and the yellow or golden: the latter is made solely of the very finest and brightest copper-dust; the former is prepared of the same material, by adding a small proportion of well pulverised red ochre. Both are applied, with varnishes, to the outside of substances, as gold leaves are in gilding. But, to prevent it from turning green, the bronzed work should, as soon as laid on, be carefully dried over a chafing-dish.

BRUNSWICK-GREEN. See COLOUR-MAKING.

BUILDING is the art of constructing and raising an edifice; in which sense it comprehends as well the expenses, as the invention and execution of the design.

In the practice of this useful art, there are five particulars to be principally attended to: 1. Situation; 2. Contrivance, or

design; 3. Strength and solidity; 4. Convenience and utility; and 5. Elegance. As our aim is not to impart elementary instructions in the art of building, we shall only sketch the most essential rules, by an attention to which, the reader may be enabled to discriminate between good and bad building, and to guard against many common errors.

In laying the foundation of a building, proper care should be taken to ascertain the nature of the soil, either by a crow or rammer; or, which is still better, with a miner's or well-digger's borer, in order to discover whether it is thoroughly sound, and fit to be laid upon it. If the foundation be not very loose it may be improved by ramming in large stones.

With regard to *situation*, a dwelling-house ought never to be erected near marshes, fens, or a boggy soil, nor too close on the banks of a river, unless it stand on a rising ground, at the north or west side of the bank.

Contrivance or *design*, is of the first importance in building, as a skilful architect will not only make the structure handsome and convenient, but often save great expences; which cannot be avoided when, by hasty and injudicious management, any future alterations become necessary. A model is the most certain way to prevent mistakes, and is superior to the best draughts. But if the latter be adopted, they should be of the largest size, so that the delineation of all the chimneys, hearths, bed-places, stairs, and the latitude of all doors and windows, in each floor, may be distinctly represented: and if the workmanship be agreed upon by the bulk, it will be useful (for obviating differences and disputes) to insert the length and thickness of the ground-plates, breast-summers, girders, trimmers, joists, raisings, and wall-plates; as also the thickness of the walls, partitions, &c. In timber buildings, the several sizes of the ground-plates, interduces, breast-summers, beams, principal port-braces, quarters, window-posts, door-posts, cellar-beams, principal rafters, &c. &c. should also be minutely ascertained.

During the 18th century, and particularly within the last forty years, great improvements have been made in the art of building; as our modern edifices are more convenient, and elegant, than those of former times. Our ancestors generally inhabited houses with a blind stair-case, low ceilings, and dark windows; the rooms were built at random, without contrivance or symmetry, and often with steps leading from one to the other; so that we might be induced to imagine, they purposely guarded against the influence of light and fresh air. The more happy genius of our age is for light stair-cases, fine sash windows, and lofty apartments. Thus, a house built according to the prevailing taste, excels both in point of compactness and uniformity; insomuch that on the same extent of ground, it affords nearly double the conveniences that could be procured on the old plan. The modern rage for building, however, is apparently attended with this unfavourable effect, that little attention is paid to the quality of the materials, and the strength of the edifice, if speculative monied men attain their object, in erecting houses that may be let at a certain rent. We believe there are few, perhaps no instances recorded in ancient history, that dwelling-houses have tumbled down before they were finished or inhabited; such events, however, have occasionally happened, especially in this metropolis. Instead of that variegated tinsel ornament bestowed on almost every chimney-piece, and other immaterial parts of a mansion, it would be more judicious and economical, to attend to the quality and durability of bricks, mortar, and timber. Nor do our modern builders, in the erection of their walls, observe that uniformity, which rendered the buildings of the Romans almost indestructible. From the description given in the 493d number of the *Philosophical Transactions*, by Mr. Arderon, it appears that the ruins of two old towers, belonging to the Roman camp at Castor, in Norfolk, were built in the following ingenious manner: They began first with a layer of bricks, laid flat as in pavements; on that they placed a layer of clay and marl mixed together, and of the same thickness with the bricks; then a layer of bricks, afterwards of clay and marl, then of bricks again; making in the whole three layers of bricks, and two of clay. Over this were placed bricks and lime twenty-nine inches, the outside being faced with bricks cut in squares; then brick and clay alternately, as high as the old ruins now standing. He adds some remarks on the hardness of the mortar, and durableness of the bricks, the length of which last is found to be 17,4-tenths inches, or a Roman foot and a half; their breadth 11,6-tenths inches, or precisely a Roman foot; and their thickness only 1,3-tenths of an inch. This last circumstance deserves particular notice, and we therefore refer the reader to the article BRICK.

Many compositions have, with more or less success, been devised for making mortar impenetrable to moisture. The following we believe is one of the most

simple and effectual: Mix thoroughly one-fourth of fresh unslacked lime with three-fourths of sand; and let five labourers make mortar in these ingredients, by pouring on water, with trowels, to supply one mason, who must, when the materials are sufficiently mixed, apply it instantly as cement or plaster, and it will become hard as stone. This recipe is given by Mr. R. Dossie, in his second volume of *Memoirs of Agriculture and other Economical Arts*, 1771. The author, on this occasion, observes that the lime used should be stone-lime; that previous to its use, it should be preserved from the access of air or wet, and the plaster screened for some time from the sun and wind. He justly remarks, that its excellence arises from the particular attraction between lime and sand, which would be destroyed by slacking the lime. Skimmed milk, (says he) is preferable to water; and for the similarity of this mortar to that of the ancients, he refers us to the celebrated Pliny, Vitruvius, &c.

Another very durable and cheap cement in building, which is particularly designed as a handsome *coping of walls*, is that of the late P. Wynah, Esq. Take four or five bushels of such plaster as is commonly burnt for floors about Nottingham, (or, according to Mr. Dossie, a similar quantity of any *turras, plaster*, or *calcined gypsum*); beat it to fine powder, then sift and put it into a trough, and mix with it one bushel of pure coal ashes, well calcined. Pour on the water, till the whole becomes good mortar. Lay this in wooden frames of twelve feet in length on the walls, well smoothed with common mortar and dry, the thickness of two inches at each side, and three inches in the middle. When the frame is moved to proceed with the work, leave an interval of two inches for this coping to extend itself, so as to meet the last frame-work.

In December 1789, Dr. R. Williams obtained a patent for the invention of a *mortar* or *stucco* for the purpose of buildings, of which we shall give the following particulars: Take of sharp, rough, large-grained sand, sifted, washed, dried, and freed from all impurities; of well burnt lime, slaked, and finely sifted; of curd, or cheese produced from milk; (the first fresh made, and strongly pressed, to divest it of its whey; the second, whilst perfectly sound, rasped into powder with a grater, or brought into a very light substance with scrapers, or fine-toothed plane irons, in a turner's lathe); and lastly, of water in its natural state, in the following proportions, viz. of the cheese, or curd, four pounds; the lime twelve pounds; the sand eighty-four pounds; the water ten pounds. If the sand is not thoroughly dried, or the lime has got damp from the air, the quantity of water must be less than the above proportion; and, on the contrary, when the lime is used as soon as slaked, it may require more; so that the proper stiffness of the mortar, under those circumstances, will regulate the making of the composition.

As the goodness of this mortar depends on the preservation of the natural properties of the cheese, or curd, made use of, all those parts the least tainted or rotten must be rejected; and as the cheese, like the curd produced from skim milk, is divested of its buttery and oily particles, and on that account possesses a powerful cohesive quality, which makes it better for this work than that made of milk in its rich and pure state; it is at all times to be bought of the wholesale cheesemongers at a lower price than any other; and being more convenient than the curd, as that will require frequent making, is to be preferred to it, as well as to every other sort of cheese; for less of it is sufficient, only four pounds being allowed to the net hundred weight of all the solid ingredients; more than which, might make the mortar too lively to keep in its place without bagging, but less should not be used; as that, on the other hand, would endanger its drying loose and gritty, within its surface, hinder it from adhering properly to the walls, and thus reduce it to the level of common mortar. Many tedious and trivial rules are stated by the patentee, relative to the manner of applying this cement, and its preservation in boxes for ready use. Those who wish to acquire additional information concerning this subject, may find the specification of the patent at full length, in the third volume of the "*Repertory of Arts and Manufactures.*" See MORTAR, CEMENT.

In July, 1796, Mr H. Walker, of Thurmaston, Leicestershire, procured a patent for his invention of a method, by which houses and other buildings, of any description or dimensions, might be erected in one entire mass or body, at a much easier expense, especially in the articles of timber, lime, and workmanship, and which would be equally as durable in themselves, and less liable to accidents by fire, than buildings erected upon the common construction. His process is as follows:

1. The patentee takes an argillaceous earth or natural clay, which he purifies by the usual well-known methods, and compounds it with sand, or broken pounded pottery or brick, coal-ashes, charcoal, or,

in short, with any other of those substances which are adapted to form a good, firm, and durable brick, when properly baked: and he varies the composition according to the nature of the component parts themselves, and the purposes which they are intended to answer; but, for common constructions, he uses the same proportions as brick-makers in general. He then proceeds to mix, knead, and incorporate the materials, till they are brought to the requisite firmness and tenacity for building; which is nearly such, that the parts of any lump or mass of the same may be readily incorporated with, or joined, to any other similar mass, by moderate blows with a wooden mallet, and the occasional addition of a very small portion of water: this composition he calls the prepared material.

2. He constructs floors, walls and all other buildings, according to this invention, in such a manner that the power of fire, from wood, coal, charcoal, coak, or other combustible matters may be applied to the external and interior surfaces of the floors, walls and other parts, by means of fires maintained in cavities left within, which he calls by the name of furnaces.

3. With respect to the particular forms, dimensions and relative positions of the floors, walls and furnaces left or formed within the same, together with the apertures or communications, for the purposes of ventilating the fires, of suffering the volatile matters to escape, and of converting the whole into one entire mass of brick, by a due communication and continuance of heat, Mr. Walker says, the ground must be rendered solid and the foundation laid in the usual manner; after which he applies a quantity of the prepared material before alluded to, and beats, rams or presses it down to the thickness of about six inches; and in width, corresponding with the intended dimensions of the wall, regulated by boards or framing. He then plants, upright, at the distance of about thirty inches asunder, in the layer or bed of prepared material, a number of cylindrical pieces of wood, of about nine inches in diameter each, and eighteen or more inches in length, to serve as moulds for the cavities of the furnaces; and between each of such moulds he places, in the longitudinal direction of the wall, a number of pipes of wood or other materials, or rods, of combustible or incombustible matter, for the purpose of forming communications between all the several furnaces, or as many of them as he thinks proper. Then he proceeds to form another layer or bed of the material, to the same height, namely, about six inches, and disposes a number of such pipes or rods, for the purpose of forming similar communications. In this manner he constructs the whole, or so much of the wall as he apprehends at the time may be conveniently formed, in the raw or unburnt state: taking care, as the work advances, to raise the wooden cylinders or moulds, that a sufficient portion of them may remain above the surface of the work, to admit of the reception and proper fashioning of each subsequent layer; or he forms the communications between the furnaces, by perforating the wooden moulds, in various places, at right angles to their respective axes; and through the said perforations he passes a bar of iron or other material, which serves to connect three or more of the said furnace-moulds; and, being afterwards withdrawn, as the work proceeds, leaves cavities of communication, similar to those formed by pipes, rods, &c. in the manner before described. Farther, he opens such a number of horizontal or oblique apertures, or flues, into all the furnaces, and likewise into all the cavities, as may be requisite for admitting, on all sides, the access of atmospheric air. In some instances he forms the horizontal or oblique apertures, or flues, by disposing, along with the pipes, a suitable number of taper-rods, which are afterwards extracted.

4. When the wall is built, he either suffers it spontaneously to dry, or promotes this effect by moderate fires in the furnaces. Sometimes by increasing the heat within, and at others, by suitable applications of fire externally, he converts the whole into one entire mass of bricks. By occasional closing or opening of the furnaces at top, or any of the other apertures, in various parts, the intelligent operator will easily understand how to regulate the progress, communication and effect of the heat, that the conversion into brick may be uniform through the entire mass.

5. The dimensions of the furnaces, the positions and relative distances of the pipes of communication and lateral apertures, and the thickness of the layers of the prepared material are each susceptible of great variations, according to the nature of this preparation, the activity of the fuel, the proposed solidity or figure of the work, &c.

6. He then forms the remaining parts of the wall or edifice, by applying additional portions of the prepared material in contact with that already baked; while he also avails himself of suitable external and internal moulds, supports,

frames, and other occasional contrivances, well known to builders, for sustaining works, or forming arches, or determining the figure and positions of soft plastic substances.

7. The ground-floor is likewise formed of the prepared material, leaving hollow spaces between the supports beneath for making fires, ventilated by side apertures, which are provided with numerous holes. When the floor is of considerable thickness, it will require the construction of furnaces, in every respect similar to those before described.

8. The first above the ground-floor is made upon suitable temporary framing, in such a manner that the upper surface shall be plane, and the lower concave, so that it may, when baked, support itself, upon the principle of a low arch.

9 and 10. The patentee constructs, bakes, or burns other floors above the first, and also the roof, &c. he closes the apertures, fills up the furnaces, amends the deficiencies, adorns the walls, floors, cielings, or other parts, with his prepared material, according to the taste and direction of the proprietor.

Various plans have lately been devised for securing buildings and ships against fire. We shall, however, only mention that of David Hartley, Esq. who, in April, 1773, obtained a patent for his invention of applying plates of metal and wire, varnished or unvarnished, to the several parts of buildings or ships, so as to prevent the access of fire, and the current of air; securing the several joints by doubling in, over-lapping, soldering, rivetting, or any other manner of closing them up; nailing, screwing, sewing, or otherwise fastening, the said plates of metal in to, and about the several parts of buildings and ships, as the case may require. Convinced that this method would be too expensive for common buildings, and that it does not afford *sufficient* security against violent flames, when the contiguous buildings are actually burning, we shall suggest other and more effectual means of protection under the article FIRE.

BUTTER, a preparation of cow's milk; which, either in its entire state, or in that of cream, is agitated for a considerable time, till all its unctuous particles are separated from the whey, and a soft consistent mass is formed.

As butter is at present, used in our daily food, chiefly on account of its agreeable taste, we shall first speak of its physical properties—To render it wholesome it ought to be perfectly fresh, and free from rancidity; which it easily acquires, if the butter-milk has not been completely separated. Fried, or burnt butter, is still more detrimental to health; as it is thus converted into an acrid, and even caustic fluid, which cannot fail to disorder the stomach, to render digestion difficult and painful, to excite rancid eructations, and ultimately to taint all the fluids with a peculiar acrimony. Hence toast and butter should never be eaten by persons who value their health; as there are many who, even by fresh butter, are affected with those inconveniences. Nor can we recommend the prevailing custom of melting butter with flour and water; for in this manner, it forms a compound more indigestible than sweet butter is in its natural state.

With respect to the various methods of making butter, we shall state only those practised in Essex, England; the farmer should never keep any cows but such as afford an abundance of milk. No milk must be suffered to remain in the udder, as by this neglect the cow will give less every meal, till at length she becomes dry before her proper time; and, the next season, will scarcely give sufficient to repay the expenses of keeping her.

If a cow's teats are scratched, or wounded, her milk will be foul, and should not be mixed with that of other cows, but given to pigs. In warm weather, the milk should remain in the pail till it is nearly cool, before it is strained; but, in frosty weather, this should be done immediately, and a small quantity of boiling water mixed with it; which will produce cream in abundance, especially in pans, or vats, of a large surface.

During the hot summer-months, the milk should stand only 24 hours, and the cream be skimmed from it, either early in the morning, before the dairy becomes warm; or in the evening, after sunset. In winter, the milk may remain unskimmed for 36, or even 48 hours; the cream ought to be preserved in a deep pan, kept, during summer, in the coolest part of the dairy, or in a cool cellar where a free air is admitted.

Those, who have not an opportunity of churning every other day, should shift the cream daily into clean pans, in order to keep it cool; but they should regularly churn twice a week in hot weather, and this in the morning before sun-rise, taking care to fix the churn in a free draught of air. Nor should this vessel be exposed to a fire so near as to heat the wood in cold seasons, as by this means the butter will acquire a strong rancidity.

A correspondent in the Papers of the *Bath and West of-England Society* observes, that the operation of churning may

be much facilitated, by adding a table-spoonful or two of distilled vinegar to a gallon of cream, but not till after the latter has undergone considerable agitation. When the butter is churned, it should immediately be washed in several waters, till it be perfectly cleansed from the milk; but a *warm hand* will soften it, and make it appear greasy. Hence it is advisable to employ two pieces of wood, such as are used by cheese-mongers; an expedient by which those who have naturally a very warm hand, might render their butter more saleable. See CHURNING.

In many parts of England, butter is artificially coloured in winter; though this process adds nothing to its goodness. The farmers in and near Epping, take sound carrots, the juice of which the express through a sieve, and mix with the cream, when it enters the churn; which makes it appear like May-butter. There is very little salt used in the best Epping butter; but it is a fact, that a certain proportion of acid, either natural or artificial, must be used in the cream, in order to ensure a successful churning. Some keep a small quantity of the old cream for that purpose; some use a little rennet, and others a few tea-spoonsful of lemon juice. Cleanliness in the dairy is, at all times, an essential requisite.

The Lancashire method of preparing milk for butter, is as follows: The whole milk is divided into two parts; the first drawn being set apart for family use, after being skimmed; the cream of which is put into proper vessels; as also the whole of the second, or last drawn milk, provincially called *afterings*. These two, being mixed together, are stirred, but not to a great depth, to prevent the bad effects of foul air accumulating on the surface, and kept, according to the season of the year, exposed to the fire, for promoting the acetous fermentation, which is accelerated by the acid remaining in the pores of the vessels. For this reason they are not scalded, except after having contracted some taint; and in this case, they are sometimes very expeditiously rinsed out with sour butter-milk: during this preparation for *souring*, the milk is kept ready for the churn; and, in consequence of such judicious treatment, more butter is obtained, and of a better quality, than if the milk were churned in a sweet state.

Decisive experiments have been made, in order to ascertain whether it be more profitable to churn the whole milk, or only the cream which the milk produces; it was found that one day's milk of a particular cow, churned by itself, yielded only 12oz. of butter; and the cream of two days milk produced 3lb. 2oz. Hence it appears to be more profitable to collect the cream, and churn it, than to churn the whole milk. Cream-butter is, likewise, the richer of the two, though it will not keep so long sweet.

In justice to Dr. James Anderson, who has favoured the public with an excellent Essay "*On the Management of a Dairy*," inserted in the correspondence of the *Bath and West-of-England Society*, we shall communicate a few of his aphorisms: 1. The first milk drawn from a cow is always thinner, and of an inferior quality to that which is afterwards obtained; and this richness increases progressively, to the very last drop that can be drawn from the udder. 2. The portion of cream rising first to the surface, is richer in quality, and greater in quantity, than what rises in the second equal space of time, and so forth: the cream continually decreasing, and growing worse than the preceding. 3. Thick milk produces a smaller proportion of cream than that which is thinner, though the cream of the former is of a richer quality. If, therefore, the thick milk be diluted with water, it will afford more cream than it would have done in its pure state; but its quality will at the same time be inferior. 4. Milk carried about in pails, or other vessels, agitated, and partly cooled, before it be poured into the milk-pans, never throws up such a good and plentiful cream as if it had been put into proper vessels immediately after it came from the cow.

From these fundamental facts, says Dr. Anderson, respecting the dairy, many very important corollaries, serving to direct the practice, may be deduced; among which we shall only take notice of the following:

First. It is evidently of much importance, that the cows should be always milked as near the dairy as possible, to prevent the necessity of carrying and cooling the milk before it be put into the dishes; and as cows are much hurt by far driving, it must be a great advantage in a dairy farm to have the principal grass-fields as near the dairy or homestead as possible. In this point of view also, the practice of feeding cows in the house rather than turning them out to pasture in the field, must, appear to be obviously beneficial.

Second. The practice of putting the milk of all the cows of a large dairy into one vessel, as it is milked, there to remain till the whole milking is finished, before any part is put into the milk-pans, seems to be highly injudicious, not only on account of the loss sustained by the agitation and

cooling; but also, and more especially, because it prevents the owner of the dairy from distinguishing the good from the bad cow's milk, so as to enlighten his judgment respecting the profit that he may derive from each. Without this precaution, he may have the whole of his dairy produce greatly debased by the milk of one bad cow, for years together, without being able to discover it. A better practice therefore would be, to have the milk drawn from each cow separately, put into the creaming-pans as soon as milked, without being ever mixed with any other: and if these pans were all made of such a size as to be able to contain the whole of one cow's milk, each in a separate pan, so that the careful *dai* (an excellent provincial word denoting the person who has the chief concern in a dairy) would thus be able to remark, without any trouble, the quantity of milk afforded by each cow every day, as well as the peculiar qualities of the cow's milk. And if the same cow's milk were always to be placed on the same part of the shelf, having the cow's name written beneath, there never could be the smallest difficulty in ascertaining which of the cows it would be the owner's interest to dispose of, and which he ought to keep and breed from.

Third. If it be intended to make butter of a *very fine quality*, it will be advisable, not only to reject entirely the milk of all those cows which yield cream of a bad quality; but also, in every case, to keep the milk that is first drawn from the cow at each milking, entirely separate from that which is got last; as it is obvious, if this be not done, the quality of the butter must be greatly debased, without much augmenting its quantity. Those who wish to be singularly nice, keep for their best butter a *very small* proportion only of the last drawn milk.

Dr. Anderson, in the same paper, imparts the following judicious hints: The milk should be forced out of the cavities of the butter with a flat, wooden ladle, or skimming dish, provided with a short handle; and this should be dexterously performed, with as little working of the butter as possible; for if it be too much beat and turned, it will become tough and gluey, which greatly debases its quality. To beat it up by the hand, is an indelicate practice. When butter is first made, and just taken out of the butter-milk, get out of it as much of the butter-milk as you can; then spread it thin over a marble-stone, or plate of clean iron, and soak up the remaining moisture by patting it with dry towels. This will tend to keep it sweet longer than otherwise. It is also very detrimental to pour cold water on the butter during this operation. If the heat should be so great, as to render it too soft to receive the impression of the mould, it may be put into small vessels, allowed to swim in the trough of cold water under the table; preventing, however, the water from touching the butter: thus it will, in a short time, acquire the necessary degree of firmness, especially if a small piece of ice be put into the vessel. The Doctor, on this occasion, severely censures the practice that prevails in many private families, of keeping fresh butter in water, and thus bringing it to table in a glass vessel. If coolness only is wanted, he advises to put the butter into a dry glass, and immerse this into cold water: and if it be taken out immediately before it is used, such butter will, in our climate, always have sufficient firmness.

After the butter has been beaten and cleared from the milk, it is ready for being salted. The vessels intended for this purpose, being rendered perfectly clean, should be rubbed in the whole inside with common salt; and a little melted butter should be poured into the cavity, between the bottom and the sides; thus prepared, they are fit to receive the butter.

The following method of preparing butter is advantageously practised in Holland. When the cows are milked, the fluid is not poured into pans, till it becomes perfectly cold; it is then stirred two or three times in the day, so that the cream and milk may more intimately combine; and if it be agitated till a spoon will nearly stand upright, the butter thus obtained is held in high esteem. As soon as the milk acquires a proper consistency, it is poured into a churn, worked for an hour, and when the butter begins to form, one or two pints of cold water are added, in proportion to the capacity of the vessel; with a view to separate the milk with greater facility.

After the butter is taken out of the churn, it is repeatedly washed and kneaded, in pure water, till the last affusion be clear and free from milk. In this simple manner, a larger portion of butter is gained from an equal proportion of milk, and which is not only more firm and sweet, but also remains fresh for a longer time, than that usually made in England, while the butter-milk is more palatable.

Dr. Anderson observes that wooden vessels are most proper for containing salted butter. They should be made of cooper-work, and joined with *wooden* hoops. It will be advisable to make them strong where they are to be returned to

the dairy; for as it is a matter of considerable difficulty to season new vessels so well, as that they shall not affect the taste of the butter, it is always advisable to employ the old sound vessels, rather than make new ones. Iron hoops should be rejected; as the rust from them will in time sink through the wood, though it be very thick, and injure the colour of the butter: one iron hoop may be put at the top, and another below and beyond the bottom; the projection below the bottom being made deep for the purpose.

An old vessel may be prepared for again receiving butter by the ordinary process of scalding, rinsing and drying; but to season a new vessel requires greater care. This is to be done by filling it frequently with scalding water, and allowing it to remain till it slowly cools. If hay, or other sweet vegetables, are put into the vessel with the water, it is sometimes thought to facilitate the process. A considerable time is required before they can be rendered fit for use.

Although common salt is generally employed for preserving butter, yet Dr. Anderson has found by experience, that the following composition not only preserves the butter more effectually from any taint of rancidity, but makes it also look better, taste sweeter, richer, and more marrowy, than if it had been cured with common salt alone. Best common salt, two parts; saltpetre, one part; sugar, one part: beat them up together, so that they may be completely blended. To every pound, or sixteen ounces of butter, add one ounce of this composition. Mix it well in the mass, and close it up for use. Butter prepared in this manner, will keep good for three years, and cannot be distinguished from that recently salted. It should, however, be remarked, that butter, thus cured, does not taste well till it has stood a fortnight, or three weeks. In the opinion of Dr. Anderson, such butter would keep sweet during the longest voyages, if it were so stowed, that it could not melt by the heat of the climate, and occasion the salts to separate from it. Hence the butter ought to be previously freed from its mucilage, which is more putrescible than the oily parts. In order to prepare it for a distant voyage, let it be put into a vessel of a proper shape, which should be immersed into another, containing water. Let this be gradually heated, till the butter be thoroughly melted; in which state it may remain for some time, and then be allowed to settle. Thus, the mucilaginous part will fall entirely to the bottom, and the pure oil will swim uppermost, perfectly transparent, while hot; but, on cooling, it becomes opaque, assumes a colour somewhat paler than the original butter, before it was melted, and acquires a firmer consistence; by which it is better enabled to resist the heat of tropical climates. When this refined butter is become somewhat firm, yet soft enough to be handled, the pure part should be separated from the dregs, then salted, and packed in the usual manner.

There is another, still more curious way of preserving this refined butter, stated by Dr. Anderson. After it is purified, add to the butter a certain portion of firm honey, mix them well, and they will thoroughly incorporate; this mixture, when spread on bread, has a very pleasant taste, and may be given to aged persons, if they relish it, instead of marrow; and to others, as being useful for coughs and colds. The proportion of honey employed was considerable; and the Doctor remarks, that this mixture has been kept for years, without acquiring the least degree of rancidity; so that there can be no doubt that butter might thus be preserved during long voyages.

Besides the different modes of *curing* butter already described, it may be easily preserved in a sweet state, by melting it down in large vessels over a slow fire; care being taken to remove the scum that rises to the surface. This method being adopted by the Tartars, we have inserted it on the authority of Mr. Eton, who states, in his late interesting *Survey of the Turkish Empire*," &c. 8vo. that he has used butter, thus boiled, and then salted, as is usual in Britain; in which state it remained perfectly sweet for the space of two years.

Butter has been sent from Philadelphia to the West Indies in summer, and kept well, by packing it in a stone jar, and pouring a strong pickle on the top, about two inches deep. The cover of the jar was secured by a cloth, and over this there was a covering of Plaister of Paris. (Gypsum.)

The food of cows very often affects the taste of butter. Thus, if wild garlic, charloc, or May-weed, be found in a pasture ground, cows should not be suffered to feed there, before the first grass has been mown; when such pernicious plants will not again appear till the succeeding spring; but milch-cows must not partake of the hay made of those plants, as it will likewise communicate their pernicious influence.

Cows should never be suffered to drink water from stagnant pools, in which there are frogs, spawn, &c.; or from common sewers, or ponds that receive the drainings of stables—all which are exceedingly improper.

For removing, or rather preventing, the bitter taste of barley-straw butter, as well as the rancidity of *turnip-butter*, Mr. Marshall suggests the following simple, and rational means. Instead of putting the cream, immediately after it is skimmed off the milk, into the jar, or other retaining vessel, it is first poured upon *hot water*, and having stood till cool, it is again skimmed off the water.

According to experiments accurately made by Mr. Joseph Wimpey, to determine the comparative value of butter and cheese, 105½ gallons of milk, properly disposed in pans for skimming off the cream, produced 36lb. of butter, and 60lb. of skimmed cheese. From a like quantity of milk were made 106lb. of raw-milk cheese, and 6lb. of whey butter. After selling the cream-butter at 8½d. and the skimmed cheese at 2d. the pound, when the raw-milk cheese, two months old, was worth 3½d. the pound, and the whey-butter 7d. it appears that a small advantage of about three per cent, lies on the side of butter and skimmed cheese.

Many abuses are practised in the packing and salting of butter, to increase its bulk and weight, against which we have an express statute. Lumps of good butter are frequently laid, for a little depth, at the top, with an inferior quality under it; sometimes the butter is set in rolls, touching only at top, and standing hollow at bottom. To prevent such deceptions, the factors employ a surveyor, who, in case of suspicion, tries the cask, or jar, with an iron instrument, made not unlike a cheese taster, and which he thrusts in obliquely to the bottom.

Lastly, we cannot omit to animadvert upon the pernicious practice of keeping milk in *leaden vessels*, and salting butter in *stone jars*, which begins to prevail, from a mistaken idea of cleanliness. But, in the hands of a cleanly person, there surely can be nothing more wholesome than wooden dishes. We fully agree with Dr. Anderson, that vessels made either of solid lead, or badly glazed, are alike destructive to the human constitution; that we may doubtless attribute to this cause the frequency of paralytic complaints which occur in all ranks of society; and that the well known effects of the poison of lead, are, bodily debility, palsy, and death.

Milk-Butter is principally made in Cheshire; where, contrary to the usual practice in other parts of the kingdom, the whole of the milk is churned, without being skimmed; preparatory to which operation, in summer, immediately after milking, the milk is put to cool in earthen jars, till it becomes sufficiently coagulated, and has acquired a slight degree of acidity, sufficient to undergo the operation of churning. This is usually performed during the summer, in the course of one or two days. In winter, in order to forward coagulation, the milk is placed near a fire; but, in summer, if it has not been sufficiently cooled, before it is added to the former milk, or, if it has been kept too close, and be not churned shortly after it has acquired the necessary degree of coagulation and acidity, a fermentation will ensue; in which case, the butter becomes rancid, and the milk does not yield that quantity, which it would, if it had been churned in proper time. This is also the case, when, in winter, the jars, or mugs, have been placed too near the fire, and the milk runs entirely to whey. No other peculiar process attends the making of this kind of butter.

Whey-Butter is so called, from its being made of whey, which is either green or white. The former is taken from the curd, out of the cheese-tub; the white whey is pressed out of the curd, by the hand or otherwise, after having been put into the cheese-vat. This kind of butter is made as follows: Sometimes the white whey, or, as it is called in Cheshire, the *thrustings*, is set in cream mugs, to acquire a sufficient degree of coagulation, and acidity, for churning, either by the warmth of the season or of a room, in the same manner as above described, for making milk-butter. In other instances, the green and the white whey are boiled together, and turned by a little sour ale, or other acid, which produces *fleetings*. In this case, when the green whey is boiled alone, it is necessary to keep up such a fire as will make the whey as hot as possible, without boiling it; and, when it has acquired that degree of heat, the butyraceous particles, which it contains, will break and separate, and rise to the surface; which effect usually takes place in the space of an hour. Care should be taken to rub the boiler, if of iron, with butter, to prevent the whey from acquiring a rancid taste. In other respects, the process of making whey-butter differs little from that of milk-butter. But the former will keep only a few days, has a marbled appearance, and does not cut so firm, or clear, as butter made of cream. One of our correspondents observes, that, in the year 1794, whey-butter was sold by contract, for the whole year, at 10d. per pound, and carried 20 miles to Manchester: he further remarks, that the *fleetings* are "nice eating," with sugar, though some epicures add wine or brandy.

Butter-Milk is that part of the milk

which remains after the butter is extracted. Curds of butter-milk are made by pouring into it a quantity of hot new milk. The quality of butter-milk greatly depends on the manner of managing the process of churning. If it be obtained according to the Lancashire mode, above described, it becomes an excellent food for man, being both wholesome and pleasant; though it is in many, English counties, given to hogs.

Good butter-milk is refreshing and cooling: hence it is often recommended in hectic fevers; for abating preternatural heat and flushings of the face. In spring, if drank freely, it is said to produce a favourable change on the fluids, when they are in a state of acrimony; and, though modern physicians smile at the idea of sweetening, or purifying the blood, yet the good effects of butter-milk, as well as sweet whey, in proper cases and constitutions, have too often been experienced, to admit of any doubt, in consequence of an unsettled theory.

C.

CALAMINE, an ore of zink. See ZINK.

CALCINATION is the reduction of solid bodies by fire, to a state of powder, or ashes: a process which is attended with a change of their quality, and is essentially different from comminution, or mechanical trituration.

Having, under the article ASHES, treated of the burning of vegetable and animal matters, we shall confine our account, in this place, to metals.

To calcine such metals as melt before ignition, they must be kept in fusion for some time; nor will this operation succeed, without a free admission of air: the surface of the metal must therefore be kept clear of the calx. Should any part be excluded from the air, no such change of quality will take place: and if any coal, or unctuous, inflammable matter, be suffered to fall into the vessel, it would reduce even the quantity, already calcined, to its former metallic state. Calcination in this sense, is nothing more than oxydation. Thus lead, by calcination, is changed into red lead, which takes place by the obsorption, and of course the combination of oxygen with the metal. Calcination has the property of precluding different calcined *calxes* or oxydes, owing to the affinity of the metal for oxygen, oxygen for caloric, &c. so that a given quantity of oxygen is absorbed. This is the reason also that some metals in calcination, will unite with different doses of oxygen. This, however, will be noticed hereafter. See REDUCTION.

CALICO-PRINTING. See PRINTING.

CALX. See LIME.

CAMPHOR. This singular vegetable substance comes to us from China. There are two kinds grow in the East, the one produced in the islands of Sumatra and Borneo, and the other produced in Japan and China. The Sumatran camphor, which the Europeans obtain, is carried to the China market, where it bears a better price than the Japanese. This has given rise to an opinion, that the Chinese buy it, to convert it, by some manipulation, into the other. The properties of the camphor we receive render this in the highest degree improbable.

Camphor is extracted from the roots, wood, and leaves of two species of laurus, the roots affording by far the greatest abundance. The method consists in distilling with water in large iron pots, serving as the body of a still, with earthen heads adapted, stuffed with straw, and provided with receivers. Most of the camphor becomes condensed in the solid form among the straw, and part comes over with the water. It is said by some to be sublimed without water; but Neumann thinks, perhaps without foundation, that such treatment would give an empyreumatic smell to the camphor. The rough camphor, as imported, resembles crude nitre or bay salt. It is imported in canisters.

The refining of camphor was long a secret in the hands of the Venetians, at the time when most of the commodities of the East were brought into Europe by that people. The Hollanders have since appropriated to themselves this, with various other manufactures dependent on chemistry; and we do not find that it is purified in large quantities elsewhere. Neumann mentions one of the largest refineries at Amsterdam, in which were fifty furnaces all managed by women. He was permitted to see the whole operation, except the charging of the vessels. The sublimation was performed in low flat-bottomed glass vessels placed in sand; and the camphor became concrete in a pure state against the upper part, whence it was afterwards separated with a knife, af-

ter breaking the glass. Lewis, in a note on this passage, asserts, that no addition is requisite in the purification of camphor; but that the chief point consists in managing the fire so that the upper part of the vessel may be hot enough to bake the sublimate together into a kind of cake. He thinks it more commodious to dissolve the crude camphor in alcohol, and, after decantation or filtration, to distil off the spirit, and fuse the camphor into a cake in a glass vessel. This is practised to advantage. Chaptal says, the Hollanders mix an ounce of quicklime with every pound of camphor previous to the distillation. The refining of camphor has been attended with success in this city, on the same plan which the Hollanders practise, as stated above.

Purified camphor is a white concrete crystalline substance, not brittle, but easily crumbled, having a peculiar consistence resembling that of spermaceti, but harder. It has a strong lively smell, and an acrid taste; is so volatile as totally to exhale when left exposed in a warm air; is light enough to swim on water; and is very inflammable, burning with a very white flame and smoke, without any residue.

The roots of zedoary, thyme, rosemary, sage, the inula helenium, the anemony, the pasque flower or pulsatilla, and other vegetables, afford camphor by distillation. It is observable, that all these plants afford a much larger quantity of camphor, when the sap has been suffered to pass to the concrete state by several months drying. Thyme and peppermint, slowly dried, afford much camphor; and Mr. Achard has observed, that a smell of camphor is disengaged when volatile oil of fennel is treated with acids. The combination of diluted nitric acid with the volatile oil of anise afforded him a large quantity of crystals, that possessed most of the properties of camphor; and he obtained a similar precipitate by pouring the vegetable alkali upon vinegar saturated with the volatile oil of angelica.

A small quantity of camphor may be obtained from oil of turpentine by simple distillation at a very gentle heat. Other essential oils however afford more. By evaporation in shallow vessels at a heat not exceeding 57° F. Mr. Proust obtained from oil of lavender ·25, of sage ·21, of marjoram ·1014, of rosemary ·0625. He conducted the operation on a pretty large scale.

Camphor is not soluble in water in any perceptible degree, though it communicates its smell to that fluid, and may be burned as it floats on its surface.

It has been observed by Romieu, that small pieces of camphor floating on water have a rotatory motion, which he ascribes to electricity.

Alcohol, ethers and oils, dissolve camphor very plentifully. The former of these dissolves much more by heat, though when cold it takes up three fourths of its own weight. The surplus taken up by heat is separated, in crystals of a plumose form, by cooling.

Nitric acid, which acts so violently on essential oils as to cause inflammation, dissolves camphor without producing heat or agitation. The camphor becomes fluid, and floats on the surface of the acid like oil, and has been called oil of camphor. Neumann says, it combines with the most concentrated part of the acid. Other acids also dissolve it. Alkalies precipitate it heavier, harder, and much less combustible.

Camphor is much used in medicine, particularly externally as a discutient. It remarkably promotes the solution of copal, and hence is of great utility in the preparation of varnishes. Its effluvia are very noxious to insects, on which account it is employed in cabinets of natural history to defend subjects from their ravages.

CANNEL COAL. See Ampelites.

CANAL, an artificial cut in the ground, which is supplied with water from rivers, springs, &c. in order to make a navigable communication between different places. There are various circumstances, upon which the particular operations, necessary for constructing navigations, depend; and which consequently increase, or diminish, the labour and expence of executing them: such as the situation of the ground; the vicinity to, or connection with rivers; the facility or difficulty with which the necessary quantity of water can be procured; and many other requisites. The utility of canals to a trading nation are too well known; we shall therefore, only refer to the following, among the many works that have lately been published on this important subject, in which the structure, economy, and advantages of canals are amply and perspicuously treated, viz. 1. Mr. Fulton's *Treatise on Canal Navigation*; 4to. Taylor, 1796. The author displays an ingenuous disposition, and a sincere wish to promote useful improvement. His work is well written, the engraving beautifully executed, and the whole is replete with useful information. 2. Mr. Chapman's *Observations on the various systems of Canal Navigation*, 4to. Taylor. This performance also abounds with useful instruction, and forms a valuable and necessary addition to Mr. Fulton's work. 3.

Mr. Tatham's *On the Political Economy of Inland Navigation, Irrigation, and Drainage*, 4to. Faulder, 1799. This work likewise contains some valuable hints, and is not destitute of utility.

CANDLE. A light made of tallow, wax, or spermaceti, the wick of which is usually composed of several threads of cotton.

There are two species of tallow candles, the one dipped, and the other moulded; the first are those in most common use; the invention of the second is attributed to Le Brege, of Paris. Good tallow candles ought to be made with equal parts of sheep and ox-tallow; care being taken to avoid any mixture of hog's-lard, which occasions a thick black smoke, attended with a disagreeable smell, and also causes the candles to run.

When the tallow has been weighed and mixed in due proportions, it is cut very small, that it may be more speedily dissolved; for otherwise it would be liable to burn, or become black, if left too long over the fire. As soon as it is completely melted and skimmed, a certain quantity of water, proportionate to that of the tallow, is poured in for precipitating the impure particles to the bottom of the vessel. This, however, should not be done till after the three first dips; as the water, by penetrating the wicks, would make the candles crackle in burning, and thereby render them useless. To purify the tallow still more, it is strained through a coarse horse-hair sieve into a tub; where, after having remained three hours, it becomes fit for use.

Wax Candles are of various kinds and forms; they are made of cotton or flaxen wicks, slightly twisted and covered with white or coloured wax. This operation is performed either by the hand or with a ladle. In order to soften the wax, it is first worked repeatedly in a deep narrow cauldron of hot water: then taken out in small pieces, and gradually disposed round the wick, which is fixed on a hook in the wall, beginning with the larger end, and diminishing in proportion as the neck approaches. To prevent the wax from adhering to the hands, they are rubbed with oil of olives, lard, or other unctuous substance. When it is intended to make wax candles with a ladle, the wicks being prepared as above-mentioned, a dozen of them are fixed at equal distances round an iron circle, which is suspended over a tinned copper vessel containing melted wax; a large ladleful of which is poured gently and repeatedly on the tops of the wicks, till the candles have acquired a proper size, when they are taken down, kept warm, and smoothed upon a walnut-tree table with a long square instrument of box, which is continually moistened with hot water, to prevent the adhesion of the wax. In other respects, this mode of making wax candles corresponds with that of manufacturing them with the hand.

From the increasing demand and price of wax, various experiments have been tried, in order to discover proper substitutes, which might possess similar solidity. We are informed by a foreign journal, that this desirable object has been satisfactorily attained, by melting down an equal quantity of tallow and resin. In order to ascertain the truth of this assertion, we were induced to repeat the experiment, but without success: for, though the two substances incorporated, they had not a sufficient degree of cohesion; and, when moulded into a proper form, the tallow burned, but the resin dissolved, and separated from it.

In September, 1799, Mr. William Bolts, of London, obtained a patent for new modes of improving the form, quality, and use of candles, and other lights, made of tallow, wax, spermaceti, &c. This invention the patentee founds on four principles: 1. On the fabrication of the body of such lights, prior to, and independently of, the wicks, which may be subsequently applied to them. 2. On the application of moveable wicks, which may be applied to, or extracted from the candles, or lights, any time after they have been made. 3. On the using of fixed, or ordinary wicks, for those lights or candles, at any period subsequent to the making of either; and 4. On placing the inflammable substance while in fusion, in a close vessel, and submitting it there to the action of a vacuum, and of a pressure superior to that of the atmosphere. This was effected with a view to extract, by the vacuum, whatever elastic fluid may remain in it, under the ordinary pressure; and also to increase the solidity and whiteness of the substance, by the superior weight applied to it, when cooling.

Although candles are preferable to lamps, as their light is less injurious both to the eyes and lungs, and as they do not produce so great a volume of smoke, yet a clean chamber-lamp, which emits as little smoke and smell as possible, is far superior even to wax candles. For, 1. As all candles burn downwards, the eye necessarily becomes more fatigued and strained during the later hours of candle-light; 2. Because they yield an irregular light, which occasions the additional trouble of snuffing them; and lastly, because, if the air be agitated ever so little, or if the

candles are made of bad materials, they injure the eye by their flaring light.

A method of making this useful article with *wooden wicks*, is practised at Munich, in Bavaria: and, as it promises to be of great utility, we lay the following account before our economical readers.

The wood generally used for this purpose, is that of the fir-tree, when one year old; though pine, willow, or other kinds are frequently employed; the young shoots must first be deprived of their bark by scraping; which operation ought to be repeated after they become dry, till they be reduced to the size of a small straw. These rods are next to be rubbed over with tallow, or wax, so as to be covered with a thin coating of either of these substances; after which they should be rolled on a smooth table, in fine *carded* cotton, of the same length as the rod or candle-mould; care being taken that the cotton be of an uniform thickness around the wick, excepting at the upper extremity, where it may be made somewhat thicker. By this preparation, the wicks will acquire the size of a small quill, when they must be placed in moulds, in the usual manner; and *good, fresh tallow*, that has previously been melted with a little water, be poured around them.

The candles thus manufactured, emit nearly the same volume of light as those made of wax: they burn considerably longer than the common tallow candles; never crackle or run; and, as they do not *flare*, are less prejudicial to the eyes of those persons who are accustomed to long continued lucubrations. It ought, however, to be observed, that a pair of sharp scissars must be employed for snuffing such candles; because, in performing that operation, great precaution is required, that the wick be neither broken nor deranged.

Prof. Hermbstadt, of Berlin, finds by experiment, that pure white-wax candles, are, with regard to the time they last, the most economical: that tallow candles, provided the wicks be in proportion to the tallow, burn the slower the smaller they are, because in larger ones a greater quantity of the substance is wasted in burning; the *oxygen* (pure air) cannot act upon the whole flame, and the increased heat disperses the combustible matter in vapour, without decomposing the air, which would augment the light. He also finds that spermaceti candles are subject to the greatest waste of any, and emit more smoke than tallow candles, although their vapour causes no disagreeable smell like them.—He thinks that those candles would be the brightest, and afford the most pleasant light, which, instead of a round, were made with a broad flat wick, or rather in the form of a hollow cylinder, that the air might act upon the flame both internally and externally.

CAOUTCHOUC. This substance, which has been improperly termed *elastic gum*, and vulgarly, from its common application to rub out pencil marks on paper, *India rubber*, is obtained from the milky juice of different plants in hot countries. The chief of these are the *Jatropha elastica*, and *Urceola elastica*. It is also obtained from the milky juices of the Indian fig, the berries of the misleto, and probably from all the vegetable barks that yield bird lime. The juice is applied in successive coatings on a mould of clay, and dried by the fire or in the sun; and when of a sufficient thickness the mould is crushed, and the pieces shaken out. Acids separate the caoutchouc from the thinner part of the juice, at once coagulating it. The juice of old plants yields nearly two thirds of its weight; that of younger plants less. Its colour, when fresh, is yellowish white, but it grows darker by exposure to the air.

The elasticity of this substance is its most remarkable property: when warmed, as by immersion in hot water, slips of it may be drawn out to seven or eight times their original length, and will return to their former dimensions nearly. In Cayenne it is used to give light as a candle. Its solvents are ether, volatile oils, and petroleum. The ether, however, requires to be washed with water repeatedly, and in this state it dissolves it completely. Pelletier recommends to boil the caoutchouc in water for an hour; then to cut it into slender threads; to boil it again about an hour; and then to put it into rectified sulphuric ether in a vessel close stopped. In this way he says it will be totally dissolved in a few days, without heat, except the impurities, which will fall to the bottom, if ether enough be employed. Berniard says the nitrous ether dissolves it better than the sulphuric. If this solution be spread on any substance, the ether evaporates very quickly, and leaves a coating of caoutchouc unaltered in its properties. Oil of turpentine softens it, and forms a pasty mass, that may be spread as a varnish, but is very long in drying. A mixture of volatile oil and alcohol dissolves it better, and dries more speedily. A solution of caoutchouc in five times its weight of oil of turpentine, and this solution dissolved in eight times its weight of drying linseed oil by boiling, is said to form the varnish of air-balloons.

Caoutchouc may be formed into vari-

ous articles without undergoing the process of solution. If it be cut into an uniform slip of a proper thickness, and wound spirally round a glass or metal rod, so that the edges shall be in close contact, and in this state be boiled for some time, the edges will adhere so as to form a tube. Pieces of it may be readily joined by touching the edges with the solution in ether: but this is not absolutely necessary, for, if they be merely softened by heat, and then pressed together, they will unite very firmly.

If linseed oil be rendered very drying by digesting it upon an oxide of lead, and afterward applied with a small brush on any surface, and dried by the sun or in the smoke, it will afford a pellicle of considerable firmness, transparent, burning like caoutchouc, and wonderfully elastic. A pound of this oil, spread upon a stone, and exposed to the air for six or seven months, acquired almost all the properties of caoutchouc: it was used to make catheters and bougies, to varnish balloons, and for other purposes.

CARMINE. See Cochineal and Colour Making.

CARPET MAKING. See Weaving.

CARROT. See Horticulture. See also Brandy.

CARTHAMUS, Safflower, or Bastard Saffron. In some of the deep reddish, yellow, or orange-coloured flowers, the yellow matter seems to be of the same kind with that of the pure yellow flowers; but the red to be of a different kind from the pure red ones. Watery menstrua take up only the yellow, and leave the red; which may afterward be extracted by alcohol, or by a weak solution of alkali. Such particularly are the saffron-coloured flowers of carthamus. These, after the yellow matter has been extracted by water, are said to give a tincture to ley; from which, on standing at rest for some time, a deep red fecula subsides, called safflower, and, from the countries whence it is commonly brought to us, Spanish red and China lake. This pigment impregnates alcohol with a beautiful red tincture; but communicates no colour to water.

Rouge is prepared from carthamus. For this purpose the red colour is extracted by a solution of the subcarbonat of soda, and precipitated by lemon juice, previously depurated by standing. This precipitate is dried on earthen plates, mixed with talc, or French chalk, reduced to a powder by means of the leaves of shave-grass, triturated with it till they are both very fine, and then sifted. The fineness of the powder and proportion of the precipitate constitute the difference between the finer and cheaper rouge. It is likewise spread very thin on saucers, and sold in this state for dyeing.

Carthamus is used for dyeing silk of a poppy, cherry, rose, or bright orange red. After the yellow matter is extracted as above, and the cakes opened, it is put into a deal trough, and sprinkled at different times with pearl ashes, or rather soda well powdered and sifted, in the proportion of six pounds to a hundred, mixing the alkali well as it is put in. The alkali should be saturated with carbonic acid. The carthamus is then put on a cloth in a trough with a grated bottom, placed on a larger trough, and cold water poured on, till the large trough is filled. And this is repeated, with the addition of a little more alkali toward the end, till the carthamus is exhausted and become yellow. Lemon juice is then poured into the bath, till it is turned of a fine cherry colour, and after it is well stirred the silk is immersed in it. The silk is wrung, drained, and passed through fresh baths, washing and drying after every operation, till it is of a proper colour; when it is brightened in hot water and lemon juice. For a poppy or fire colour a slight annotta ground is first given; but the silk should not be alumed. For a pale carnation a little soap should be put into the bath. All these baths must be used as soon as they are made; and cold, because heat destroys the colour of the red feculæ.

CASE-HARDENING. Steel when hardened is brittle, and iron alone is not capable of receiving the hardness steel may be brought to possess. There is nevertheless a variety of articles in which it is desirable to possess all the hardness of steel, together with the firmness of iron. These requisites are united in the art of case-hardening, which does not differ from the making of steel, except in the shorter duration of the process. Tools, utensils, or ornaments intended to be polished, are first manufactured in iron and nearly finished, after which they are put into an iron box, together with vegetable or animal coals in powder, and cemented for a certain time. This treatment converts the external part into a coating of steel, which is usually very thin, because the time allowed for the cementation is much shorter, than when the whole is intended to be made into steel. Immersion of the heated pieces into water hardens the surface, which is afterward polished by the usual methods. Moxon's *Mechanic Exercises*, p. 56, gives the following receipt:—Cow's horn or hoof is to be baked or thoroughly dried, and pulverized. To

this add an equal quantity of bay salt; mix them with stale chamberley, or white wine vinegar; cover the iron with this mixture, and bed it in the same in loam, or enclose it in an iron box: lay it then on the hearth of the forge to dry and harden: then put it into the fire, and blow till the lump have a blood red heat, and no higher, lest the mixture be burned too much. Take the iron out, and immerse it in water to harden.

CASTOR-OIL. Castor-oil is extracted from the kernel of the fruit, produced by the ricinus Americanus, or oil-nut tree, which grows in many parts of America, and is now much cultivated in Jamaica, and in the United States. It is raised from the nut or seed, grows with a surprising rapidity to the height of fifteen or sixteen feet, and seems to flourish most in gullies, or near running water, in cool shady spots. The seeds being freed from the husks or pods, which are gathered upon their turning brown, and when beginning to burst open; are first bruised in a mortar, afterwards tied up in a linen bag, and then thrown into a large pot, with a sufficient quantity of cold water (about eight gallons to one gallon of seeds), and boiled till their oil is risen to the surface; this is carefully skimmed, strained, and kept in tight bottles for use. One gallon of nuts, will yield about one quart of oil. Thus prepared, it is entirely free from all acrimony, and will freely stay upon the stomach, when most other medicines are rejected.

But when intended for medicinal use, the oil is more frequently cold drawn, or extracted from the bruised seeds, by means of a hand-press; though this is thought more acrimonious than what is prepared by coction. The cold drawn oil, at first is perfectly limpid; but after being kept for some time, acquires the appearance of a pale tincture, resembling Lisbon wine, probably caused by the membrane, which covers the kernels.

This plant thrives in almost every soil, and should be cultivated in every garden, on account of its great importance in medicine, it being used internally, as a gentle purgative, and externally for removing spasms, cramps, &c. the plant is cultivated largely, as an article of profit, in Kentucky, New-York, and some of the New-England states. In the sandy soils of Georgia, South Carolina and the Floridas, it grows to a great size and is very prolific.

CATECHU, see TANNIN.

CATTLE, see ANIMALS DOMESTIC, see also BREEDING of CATTLE.

CEDAR, or the *Pinus Cedrus*, is of a coniferous evergreen of the bigger sort, bearing large roundish cones of smooth scales, standing erect, the leaves being small, narrow, and thick set.

Cedar-wood is reputed almost immortal, and incorruptible; a prerogative which it owes chiefly to its bitter taste, which the worms cannot endure.

As this tree abounds with us, it might and ought to have a principal share in our most superb edifices. The aromatic effluvia, constantly emitted from its wood, is said to purify the air and make rooms wholesome. On account of the great durability of cedar wood it was, that the ancients used cedar tablets to write upon, especially for things of importance. A juice was also drawn from cedar, with which they smeared their books and writings, or other matters, to preserve them from rotting, and the destruction caused by the worms. Plantations of this beautiful tree might conduce to the ornament as well as convenience of domestic life: for the wood of cedar is not subject to the depredations of insects, and is admirably calculated to withstand the effects of moisture: hence attempts have been made to imitate it, by dyeing inferior wood of a red colour: but the fraud may be easily detected by the smell, as that of the cedar is very aromatic. Besides the numerous articles of the cabinet-maker and joiner, the wood of cedar is also made into moulds for black lead pencils.

Cedar, Red and White. These two celebrated trees are of different genera. The first is the *Juniperus Virginiana*, and the latter, *Cupressus Thyoides*. The red cedar is famous in America for affording the most durable fence posts, and in Bermuda for its durable and light timber, in the construction of fast sailing vessels, In Virginia and Carolina the berries of this treee are distilled into brandy. The wood is said to preserve furs or woollens enclosed in boxes of it from being touched by moths. The white cedar affords one of the most useful woods in the United States, particularly for covering houses, and other buildings: most of the houses of Philadelphia are roofed with shingles made of this wood. It is preferred to all other wood for the purpose before mentioned, as well as for fence rails, boarding frame buildings, and all sorts of inside work of houses, particularly, where paint, varnishing, or paper hangings are intended; it is preferred to all other wood, for coopers-ware, such as wooden cisterns, tubs, pails, churns, &c.

This celebrated tree possesses an extensive range on the Atlantic coasts from New England southward as far as,

East and West Florida. Its natural situation and soil is the flat country near the sea shore and fifty or sixty miles back, where swamps, or a wet morassy soil abounds, but will grow very well if planted in higher land, provided the soil be sandy and moist.

CIELING, in architecture, is the top, or roof, and sides of a room, made of plaster, laid over laths nailed on the bottom of the joist of the upper room; or, where there is no upper room, on joists made for that purpose, which are therefore called *cieling joists*.

Plastered cielings are in much greater use in America than in any other country; they are preferable to papered, or other cielings, as they make a room not only lighter, but also prevent the dust from penetrating through crevices; lessen the noise from above; check the progress of accidental fires; and, during summer, contribute to cool the air. See CEMENT.

CEMENT. Whatever is employed to unite or cement together things of the same or different kinds may be called a *cement*. In this sense it includes LUTES, GLUES, and SOLDERS of every kind, but it is more commonly employed to signify those of which the basis is an earth or earthy salt. We shall here enumerate some cements that are used for particular purposes, and in the following article mention calcareous cements, such as mortar, tarras and other substances, used to close the joinings of bricks or stones, in buildings.

Seven or eight parts of resin, and one of wax, melted together, and mixed with a small quantity of plaister of Paris, is a very good cement to unite pieces of Derbyshire spar, or other stone. The stone should be made hot enough to melt the cement, and the pieces should be pressed together as closely as possible so as to leave as little as may be of the cement between them. This is a general rule in cementing, as the thinner the stratum of cement interposed, the firmer it will hold.

Melted brimstone used in the same way will answer sufficiently well, if the joining be not required to be very strong.

It sometimes happens, that jewellers, in setting precious stones, break off pieces by accident: in this case they join them so that it cannot easily be seen, with gum mastic, the stone being previously made hot enough to melt it. By the same medium cameos of white enamel or coloured glass are often joined to a real stone as a ground, to produce the appearance of an onyx. Mastic is likewise used to cement false backs, or doublets, to stones, to alter their hue.

The jewellers in Turkey, who are generally Armenians, ornament watch-cases and other trinkets with gems by glueing them on. The stone is set in silver or gold, and the back of the setting made flat to correspond with the part to which it is to be applied. It is then fixed on with the following cement. Isinglass, soaked in water till it swells up and becomes soft, is dissolved in French brandy, or in rum, so as to form a strong glue. Two small bits of gum galbanum, or gum ammoniacum, are dissolved in two ounces of this by trituration: and five or six bits of mastic, as big as pease, being dissolved in as much alcohol as will render them fluid, are to be mixed with this by means of a gentle heat. This cement is to be kept in a phial closely stopped; and when used, it is to be liquefied by immersing the phial in hot water. This cement resists moisture.

A solution of shell lac in alcohol added to a solution of isinglass in proof spirit makes another cement that will resist moisture.

So does common glue melted without water with half its weight of resin, with the addition of a little red ochre to give it a body. This is particularly useful for cementing hones to their frames.

If clay and oxide of iron be mixed with oil, according to Mr. Gad of Stockholm, they will form a cement, that will harden under water.

A strong cement, insoluble in water, may be made from cheese. The cheese should be that of skimmed milk, cut into slices, throwing away the rind, and boiled till it becomes a strong glue, which however does not dissolve in the water. This water being poured off, it is to be washed in cold water, and then kneaded in warm water. This process is to be repeated several times. The glue is then to be put warm on a levigating stone, and kneaded with quicklime. This cement may be used cold, but it is better to warm it; and it will join marble, stone, or earthenware, so that the joining is scarcely to be discovered.

Boiled linseed oil, litharge, red lead, and white lead, mixed together to a proper consistence, and applied on each side of a piece of flannel, or even linen or paper, and put between two pieces of metal before they are brought home, or close together, will make a close and durable joint, that will resist boiling water, or even a considerable pressure of steam. The proportions of the ingredients is not material, but the more the red lead predominates the sooner the cement will dry, and the more the white lead the contrary.

This cement answers well for joining stones of any dimensions.

The following is an excellent cement for iron, as in time it unites with it into one mass. Take 2 ounces of muriat of ammonia, 1 of flour of sulphur, and 16 of cast iron filings or borings. Mix them well in a mortar, and keep the powder dry. When the cement is wanted for use, take one part of this mixture, twenty parts of clear iron borings or filings, grind them together in a mortar, mix them with water to a proper consistence, and apply them between the joints.

Powdered quicklime mixed with bullock's blood is often used by coppersmiths, to lay over the rivets and edges of the sheets of copper in large boilers, as a security to the junctures, and also to prevent cocks from leaking.

Six parts of clay, one of iron filings, and linseed oil sufficient to form a tough paste, make a good cement for stopping cracks in iron boilers.

Temporary cements are wanted in cutting, grinding, or polishing optical glasses, stones, and various small articles of jewellery, which it is necessary to fix on blocks or handles, for the purpose. Four ounces of resin, a quarter of an ounce of wax, and four ounces of whiting made previously red hot, is a good cement of this kind; as any of the above articles may be fastened to it by heating them, and removed at pleasure in the same manner, though they adhere very firmly to it when cold. Pitch, resin, and a small quantity of tallow, thickened with brick-dust, is much used at Birmingham for these purposes. Four parts of resin, one of bees wax, and one of brick-dust, likewise make a good cement. This answers extremely well for fixing knives and forks in their hafts; but the manufacturers of cheap articles of this kind too commonly use resin and brick dust alone. On some occasions, on which a very tough cement is requisite, that will not crack though exposed to repeated blows; as in fastening to a block metallic articles, that are to be cut with a hammer and punch; workmen usually mix some tow with the cement, the fibres of which hold its parts together.

From the vast variety of receipts for lutes and cements of different kinds the following may be selected, which will answer most of the purposes of the experimental chemist.

To prevent the escape of the vapors of water, spirit, and liquors not corrosive, the simple application of slips of moistened bladder will answer very well for glass, and paper with good paste for metal. Bladder to be very adhesive should be soaked some time in water, moderately warm, till it feels clammy, it then sticks very well. If smeared with white of egg instead of water, it adheres still closer.

Another very convenient lute is linseed meal moistened with water to a proper consistence, well beaten, and applied pretty thick over the joinings of the vessels. This immediately renders them tight, and the lute in some hours dries to a hard mass. Almond paste will answer the same purpose.

The use of the above lute is so extensive, that no other is required in closing glass vessels, in preparing all common distilled liquors, and it will even keep in ammonia and acid gasses for a longer time than is required for most experimental purposes. It begins to scorch and spoil at a heat much above boiling, and therefore will not do as a *fire lute.* It is still firmer and dries sooner when made up with milk, or lime water, or weak glue.

A number of very cohesive cements impervious to water, and most liquids, and vapors, and extremely hard when once solidified, are made by the union of quicklime with many of the vegetable or animal mucilaginous liquors. The variety of these is endless. We may first mention the following, as it has been extensively employed by chemists for centuries. Take some whites of eggs with as much water, beat them well together, and sprinkle in sufficient slacked lime to make up the whole to the consistence of thin paste. The lime should be slacked by being once dipped in water, and then suffered to fall into powder, which it will do speedily with great emission of heat, if well burnt. This cement should be spread on slips of cloth and applied immediately, as it hardens or *sets* very speedily. While hardening, it may be of use to sprinkle over it some of the lime in fine powder. This cement is often more simply, and as conveniently, managed, by smearing slips of linen on both sides with white of egg, and, when applied to the joining of the vessel, shaking some powdered lime over it. It then dries very speedily.

Another lute of the same kind, and equally good, is made by using a strong solution of glue to the lime, instead of the white of egg. It sets equally soon, and becomes very hard. A mixture of liquid glue, white of egg, and lime, makes the *lut d'ane,* which is so firm that broken vessels united with it are almost as strong as when sound. None of these lutes however will enable these vessels to hold liquids for any great length of time. Milk

or starch with lime make a good but less firm lute.

A very firm and singular lute of this kind is made by rubbing down some of the poorest skimmed-milk cheese with water to the consistence of thick soup, and then adding lime and applying as above. It answers extremely well. Lime and blood, with a small quantity of brick-dust or broken pottery stirred in, is used in some places as a very good water cement for cellars and places liable to damp.

Plaster of Paris mixed with egg, milk, glue, starch, or any mucilaginous liquor, also makes a good lute.

Some artists mix other earths with the above materials. Thus, a very good cement is made with equal parts of clay and lime, about one-third of flour and white of egg; or, as is used by many of the aqua-fortis makers, a mixture of colcothar, lime, and white of egg.

All the above-mentioned cements with lime become very hard by drying, insomuch that they cannot be separated from glass vessels without the help of a sharp knife and some violence, and hence delicate vessels and long thin tubes cemented with it are apt to break when the apparatus is taken down, and sometimes even by the mere force of contraction in setting. It is a great advantage however, that they may be applied immediately to any accidental crack or failure of the lute already on, notwithstanding a stream of vapour is bursting through, and in large distillations it is of advantage always to have some of the materials at hand.

These lutes will not confine very corrosive acid vapours perfectly for a great length of time, but will answer for other purposes, particularly where a complicated apparatus is to be kept steadily united and air-tight. They will bear nearly a red-heat without material alteration.

Another kind of lute which is the most perfect for confining acid vapours for any length of time, and which never hardens to an inconvenient degree, is the *fat lute* as it is called. This is made by taking any quantity of good clay, tobacco-pipe clay for example, thoroughly dry, but not burnt, powdering it in an iron mortar, mixing it gradually with *drying* linseed oil, and beating them for a long time to the consistence of thin paste. Much manual labour is required, and it should be continued till the mass no longer adheres to the pestle. Then, make the edges of the glass or other vessels where it is to be used, perfectly dry, and apply the lute carefully, and it will stand the longest process without failing. This grows firm enough to retain its place and to hold the vessels together, but may readily be separated by a knife. This lute much improves in adhesiveness by long keeping, which should be in a covered pan in a cool cellar. When wanted, it regains sufficient ductility merely by being beaten for a minute or two, or by the help of a few drops more of the oil. Good glaziers putty, which is made of chalk beat up with drying linseed oil, much resembles the fat lute in quality.

Often a fire lute is required to join the covers to crucibles, or for similar purposes, so as to keep them air-tight when hot. A very valuable composition of the kind is made of glass of borax, brick-dust, and clay, finely powdered together and mixed with a little water when used. No very great nicety is required in the proportions, but about a tenth of borax is quite sufficient to bring the earths to that state of semi-vitrification which is desired. Litharge may also be used instead of borax, but the latter is by far the best, as it promotes that thin spreading fusion which is best calculated to be equally applied over an uneven surface, and besides, if a portion of the litharge-lute were to drop into the crucible it might possibly be reduced, and lead introduced into the results of the experiment.

A cement said to be useful to stop cracks of iron vessels intended to be strongly heated, is made of 6 parts of clay, 1 of iron filings, and linseed oil enough for mixture.

Another species of cement is what is termed by the French *Mastich chaud*, and consists of different kinds of oily and resinous substances, liquid when hot, and which become more or less solid by cooling. They are useful for a variety of miscellaneous purposes, for experiments with gasses over water or mercury, and others where only a very moderate warmth is used, and where it is of importance to keep out air and water. These will also confine acid vapours, but not the vapours of alcohol, turpentine, or essential oils, which dissolve most resinous substances. Most of them will stick very well to glass. Common sealing-wax is one of the most useful of these cements. A cheaper and less brittle cement is made simply by melting bees wax with about one-eighth of common turpentine. This may be made up into sticks to be used when wanted, being first melted or spread evenly with a hot iron. A greater portion of turpentine renders this lute softer, and more fusible, but somewhat pliable.

Chaptal, found after many trials, that the penetrating vapours of sulphureous acid

in the manufacture of alum were completely confined in a wooden chamber, lined very carefully with a mixture of equal parts of pitch, turpentine, and wax, boiled till all the essential oil was dissipated (which was known by the cessation of the bubbles) applied melted to the wood, and spread with a hot trowel over the joints. Vintners stop leaks in their casks with melted suet rubbed over, when cooling, with sifted wood-ashes, or previously mixed with the ashes in melting.

The use of gum arabic dissolved in water for cementing paper lables to bottles, and a great variety of miscellaneous purposes is known to every one. A still better cement for the same uses is isinglass dissolved in vinegar to a pretty thick consistence when warm. This congeals on cooling, and before it is used it should be gently warmed.

Many of the varnishes and oil paints are employed in rendering vessels air and water tight.

The following cement is said to be very useful in joining together glass or steel. Take of mastich five or six bits as big as peas, dissolve in as much alcohol as will render them liquid. In another vessel dissolve as much isinglass (previously soaked in water) in brandy or rum, as will make two ounces by measure of a strong glue; warm it, and incorporate with it, by rubbing, two or three small bits of galbanum or ammoniacum, and then the mastich solution. Keep the cement in a bottle well stopped, and gently warm it before use.

Those fusible metallic compounds used to unite pieces of metal, form another totally distinct species of cements. These are termed Solders, under which they will be described.

Some inconveniences occasionally attend the use of these lutes in chemical operations. The application of them takes up time and requires a little manual dexterity, which can only be learned by practice.

It may be added, that the modern use of Woulfe's apparatus, or similar contrivances, so completely takes away the pressure of expansive vapours in all distillations, that in many instances very simple lutes will answer now, where formerly it was necessary to render the joinings of vessels as firm as the vessels themselves. But the proper application of all these kinds of cements is of great importance to the practical chemist to prevent continual losses and disappointments.

CEMENTS, CALCAREOUS. In this article it is proposed to give an account of the various cements used in building, into which lime enters as an essential constituent part; and in order to treat the subject with a degree of clearness in some measure corresponding to its importance, it will be advisable to arrange every kind of calcareous cement under one or other of the following three divisions. First, simple calcareous cement: secondly, water cements: thirdly, mastichs or maltha.

1. *Simple Calcareous Cements.*—This section includes those kinds of mortar which are employed in buildings on land; and generally consist of lime, sand, and fresh water.

The various kinds of marble, chalk, and lime stone, as far as regards their use in cements, may be divided into two species; the first being pure, or nearly pure carbonat of lime, the second containing besides from $\frac{1}{20}$ to $\frac{1}{12}$ of clay and oxyd of iron. Previous to burning or calcination, there are no external characters by which the simple limestones can be distinguished from the argillo-ferruginous ones; but the former, whatever may have been their colour in the crude state, become, when calcined, of a white colour, while the latter possess more or less of a light ochery tinge. The brown lime is by far the best for all kinds of cements, but the white varieties being more abundant, and allowing of a larger proportion of sand, are generally made use of. It was an opinion of the ancients, and is still commonly received among architects, that the hardest lime stone, *ceteris paribus*, furnishes the best lime; hence marble was considered as superior to common limestone, and this latter to chalk. The experiments of Mr. Smeaton, however, show that this is entirely a mistake; common chalk and the hardest Plymouth marble, when similarly treated, affording cements of equal firmness.

When carbonated lime has been thoroughly burnt, it is deprived of its water, and of all, or nearly all of its carbonic acid; if in this state it is plunged into water, and immediately taken out again, the water which it has absorbed will occasion the mass to crack and become excessively hot, and at length to fall into an impalpable powder, much of the water being carried off in the form of steam during the process. When lime has been thus slacked, if it is beaten up with a little water into a very stiff paste and allowed to dry, it will be found that the white limes, whether from chalk or marble, never acquire any degree of hardness, that the brown limes become considerably indurated, though not so much so as when

mixed with sand, and that shell lime (procured by calcining sea-shells) concretes into a firm hard cement, well qualified for dry building, although it falls to pieces in water.

A proper selection of sand is of great importance in the composition of mortar; the sharper and coarser it is, the better, both because it requires a smaller proportion of lime, which is the most costly ingredient, and because the mortar thus prepared is stronger than when fine grained and round sand is made use of. Sea sand requires to be well washed in fresh water to dissolve out the salt with which it is mixed, otherwise the cement, into which it enters, never becomes thoroughly dry and hard. The Roman builders were accustomed to allow four parts of coarse sharp pit sand, and only three parts of river or sea sand to one of lime. If, however, the cement was required to be very compact, the proportion of lime was increased: thus the mortar used in constructing reservoirs for water, consisted of two parts of the strongest lime and five parts of pure and sharp sand.

The weakness of modern mortar compared to the ancient is a common subject of regret, and many ingenious men, taking for granted that the process used by the Roman architects in preparing their mortar is one of those arts which are now lost, have employed themselves in making experiments to recover it, instead of attending to the directions left us in Pliny and other authors, which when illustrated by the actual practice of builders in various parts of Europe, seem to leave little or no doubt on the subject.

The characteristic of all modern artists, builders among the rest, seems to be to spare their time and labour as much as possible, and to increase the quantity of the articles they produce without much regard to their goodness; and perhaps there is no manufacture in which this is so remarkably exemplified as in the preparation of common mortar.

One radical fault is the use of chalk instead of stone lime, for although chalk when perfectly burnt is equally good as the hardest lime, yet it possesses two capital disadvantages; first, it will fall into a coarse powder on the application of water, when it is only partially calcined, which stone lime will not; and secondly, the cores or unburnt lumps may be broken down by a blow with the spade, and are therefore very seldom rejected as they ought to be.

The method of preparing common mortar is extremely imperfect. The lime being slacked by the addition of water, and the unburnt lime being broken down and mixed with the rest, a large quantity of dirty sand is added, and the whole being incorporated by means of a spade is reckoned to be fit for use; thus the principal point in the making of mortar, namely, beating the ingredients together so as to mix them thoroughly, is slurred over in a hasty careless manner, and the result, as might be expected, is a crumbling mass scarcely fit for use. The Roman builders, on the other hand, after they had mixed together the materials, employing for this purpose a smaller proportion of water than is customary at present, put the mass into a large wooden mortar, and beat it, till it ceased to adhere to the heavy wooden or iron pestle which was used on the occasion. A practice this which has been followed by the Dutch with complete success, as will be shown in the next section, and the high utility of which is also proved by Mr. Smeaton, in his history of Eddystone light-house.

Fresh made mortar, if kept under ground in considerable masses, may be preserved for many months without injury; and the older it is before it is used the better, the builder taking the precaution to beat it up afresh previously to using it; for it not only sets sooner, but acquires a greater degree of hardness, and is less apt to crack. Pliny informs us, that the ancient Roman laws prohibited builders from using mortar that was less than three years old, and to this circumstance he expressly attributes the remarkable firmness of the oldest buildings in the city. A similar law prevailed, and, we believe, still prevails in Vienna, requiring the mortar to be a year old before it is employed. But there is nothing which shows in so striking a point of view the advantage and necessity of beating mortar, and that the effect produced is owing to something more than a mere mechanical mixture of the ingredients, as the preparation of *grout* or liquid mortar. This differs from common mortar only in containing a larger quantity of water, so as to be sufficiently fluid to penetrate the narrow irregular cracks and interstices of rough stone walls, and is generally made by diluting common mortar with water either cold or hot. It not unfrequently happens that this grout refuses to set, and at all times it is a long while in acquiring the proper hardness: but if instead of common mortar, that which has been long and thoroughly beaten is employed, the grout will set in the space of a day, and soon after acquire a degree of hardness much superior to what is made in the common manner.

2. *Water Cements.*—Although a well made mortar, composed merely of sand and lime, if allowed to dry, becomes impervious to water, so as to serve for the lining of reservoirs and aqueducts, yet if the circumstances of the building are such as to render it impracticable to keep out the water whether fresh or salt a sufficient length of time, the use of common mortar must be abandoned; for lime and sand if mixed together in any proportions, and put while soft into water, will in a short time fall to pieces.

Among the nations of antiquity the Romans appear to have been the only people who practised building in water, and especially in the sea, to any great extent. The bay of Baiæ, like our fashionable watering places, was the summer resort of all the wealthy in Rome, who not content with erecting their villas as near the shore as possible, were accustomed to construct moles, and form small islands in the more sheltered parts of the bay, on which, for the sake of the grateful coolness, they built their summer houses and pavilions. They were enabled to build thus securely in the water, by the fortunate discovery, at the neighbouring town of Puteoli of an earthy substance, which, from this circumstance, was called *pulvis Puteolanus* (powder of Puteoli). Puteolan powder, or as it is now denominated Puzzolana, is a light, porous, friable mineral of a red colour, and is generally supposed to derive its origin from concreted volcanic ashes thrown out from Vesuvius, near to which mountain the town of Puteoli is situated: it seems to consist of a ferruginous clay baked and calcined by the force of volcanic fire, and when mixed with common mortar, not only enables it to acquire a remarkable hardness in the air, but to become as firm as stone, even under water. The only preparation which puzzolana undergoes is that of pounding and sifting, by which it is reduced to a coarse powder: in this state, being thoroughly beaten up with lime, either with or without sand, it forms a mass of remarkable tenacity, which speedily sets under water, and becomes at least as strong as good freestone. In the composition of water cements it is that the superior efficacy of argillo-ferruginous lime, compared with the purer kinds, is most strikingly manifest; and as building in water is generally very expensive and difficult to repair, every precaution should be taken to secure the goodness of the cement. In situations exposed to the violent shocks of the sea, the difference of expense between the best and inferior kinds of mortar is so little, compared to the whole cost and the satisfaction of perfect security that the cement ought to be of the very best quality. That which was used by Mr. Smeaton, in the construction of Eddystone light-house, was composed of equal parts by measure of slacked Aberthaw lime and puzzolana; but for works that are less exposed, such as locks and basons for canals, &c. the proportions of puzzolana may be considerably diminished. A composition of this kind, which has been found very effectual, is two bushels of slacked Aberthaw lime, one bushel of puzzolana, and three of clean sand; the whole being beaten well together with the proper quantity of water, will yield 4·67 cubic feet of cement.

The Dutch have practised building in water to a greater extent than any other nation of modern Europe; and to them is due the discovery of a cement admirably well qualified for this purpose, and called tarras or trass. This is nothing more than wakke or cellular basalt; and is procured chiefly from Bockenheim, Frankfort on the Maine, and Andernach, whence it is transported down the Rhine in large quantities to Holland. It undergoes no further preparation than grinding and sifting, and being thus reduced to the consistence of coarse sand it is beaten up with the blue argillaceous lime from the banks of the Scheld, and thus composes the celebrated tarras mortar with which the mounds and other constructions for the purpose of protecting the lowlands of Holland against the sea are cemented. The strongest tarras mortar is composed of two measures of slacked lime, and one of tarras; another kind almost equally good and considerably cheaper, is made of two measures of slacked lime, one of tarras, and three of coarse clean sand; it requires to be beaten a longer time than the foregoing, and produces three and an half measures of excellent mortar. When the building is constructed of rough irregular stones, where cavities and large joints are to be filled up with cement, the pebble mortar may be most advantageously applied: this was a favourite mode of construction among the Romans, and has been used ever since their time in those works in which a large quantity of mortar is required. Pebble mortar will be found of sufficient compactness, if composed of two measures of slacked argillaceous lime, half a measure of tarras or puzzolana, one measure of coarse sand, one of fine sand, and four of small pebbles, screened and washed. Although the cellular basalt is the only kind admitted into the preparation of Dutch tarras, yet it appears from some good expe-

riments of Morveau on the subject, that the common compact basalt, if previously calcined, will answer nearly the same purpose. The compact basalt abounds in all the districts where coal is raised, and may therefore be procured easily, and calcined with the refuse coal, so as to be sold at a cheap rate.

In some parts of the Low Countries coal ashes are substituted for tarras with very good effect, of which the valuable *cendrée de Tournay* is a striking instance. The deep blue argillo-ferruginous lime-stone of the Scheld is burnt in kilns with a slaty kind of pit coal that is found in the neighbourhood: when the calcination of the lime is completed, the pieces are taken out, and a considerable quantity of dust and small fragments remain at the bottom of the kiln. This refuse consists of coal ash mixed with about one quarter of lime dust, from which the cendrée is thus prepared. About a bushel of the materials is put in any suitable vessel, and sprinkled with water, just sufficient to slack the lime; another bushel is then treated in the same way, and so on till the vessel is filled: in this state it remains some weeks, and may be kept for a much longer time if covered with moist earth. A strong open trough, containing about two cubic feet, is filled about two-thirds full with the cement in the above state, and by means of a heavy iron pestle, suspended at the end of an elastic pole, is well beaten for about half an hour; at the end of this time it becomes of the consistence of soft mortar, and is then laid in the shade from three to six days, according to the dryness of the air; when sufficiently dry, it is beaten again for half an hour as before, and the oftener it is beaten, the better will be the cement; three or four times however are sufficient to reduce the cement to the consistence of an uniform smooth paste; after this period it is apt to become refractory on account of the evaporation of its water, as no more of this fluid is allowed to enter the composition than what was at first employed to slack the lime. The cement thus prepared is found to possess the singular advantage of uniting, in a few minutes, so firmly to brick or stone, that still water may be immediately let in upon the work without any inconvenience; and by keeping it dry for twenty-four hours, it has afterwards nothing to fear from the most rapid current.

Somewhat analogous to the preceding is a cement used in certain parts of England with advantage, and called ash-mortar. It is prepared by slacking two bushels of fresh burnt meagre lime, and mixing it accurately with three bushels of wood-ashes: the mass is to lie till it is cold, and is then to be well beaten: in this state it will keep a considerable time without injury, and even with advantage, provided it is thoroughly beaten twice or thrice before it is used.

The scales of black oxyd which are detached by hammering red-hot iron, and are therefore to be procured at the forges and blacksmiths' shops, have been long known as an excellent material in water cements, but we believe that Mr. Smeaton was the first person who made any accurate experiments on their efficacy compared with other substances. The scales being pulverized and sifted, and incorporated with the lime in the same manner as puzzolana, are found to produce a cement equally powerful with puzzolana mortar, if employed in the same quantity. Induced by the success of these experiments, Mr. Smeaton substituted roasted iron ore for the scales, and found that this also gave to mortar the property of setting under water: it requires however to be used in greater proportions than either tarras or puzzolana: two bushels of argillaceous lime, two of iron ore, and one of sand, being mixed with the same care as we have already mentioned, produce 3·22 cubic feet of cement fully equal to tarras mortar. If the common white lime is made use of, it will be adviseable to employ equal quantities of all the three ingredients.

Nothing more remains to be said on this part of the subject but a few words concerning the choice of the water by which the several ingredients of the cement are to be mingled together. River or pond water, where it can be had easily, is to be preferred to spring water; but for works exposed to the action of the sea, such as piers, light-houses, &c. it is usually more convenient, and equally advantageous in other respects to use salt water. The great point, and which is too often neglected, is not to put in too much of either one or the other: it is infinitely better to employ no more than is requisite to slack the lime, and so incorporate the materials at the expense of a little more labour, than by a superfluity of water to bring the whole to the proper consistence without beating.

3. *Maltha or Mastich.*—Under this term we include those calcareous cements of a more complicated kind, whose hardness appears to depend on the oily and mucilaginous substances that enter into their composition. The use of these is at present very limited, at least in Europe; but they were highly esteemed by the

ancients, especially for stucco. The maltha of the Greeks seems to have been more simple than that employed by the Roman architects; at least, we are informed that Panænus, the brother of Phidias, lined the inside of the temple of Minerva at Elis, with a stucco, in which the usual materials (sand and lime) were mixed up with milk instead of water, some saffron being also added to give it a yellow tinge. The Roman maltha, according to Pliny, was prepared in the following manner. Take fresh burnt lime, slack it with wine, and beat it up very well in a mortar with hogs'-lard and figs: this cement, if well made, is excessively tenacious, and in a short time becomes harder than stone: the surface to which it is to be applied is to be previously oiled in order to make it adhere. Another kind almost equally strong, and considerably cheaper, was prepared by beating up together fine slacked lime, pulverized iron scales, and bullock's blood. In the preparation of mastichs, as well as of every other kind of mortar, so much depends on the manipulation, and especially on the care which is taken to incorporate the ingredients by *long* beating, that those countries in which labour is of the least value, possess in general the best mortar. Hence, no doubt, principally arises the unrivalled excellence of the mortar made by the Tunisians and other inhabitants of the northern coast of Africa, which, according to Dr. Shaw, is prepared in the following manner. One measure of sand, two of wood ashes, and three of lime, being previously sifted, are mixed together, and sprinkled with a little water; after the mass has been beaten for some time, a little oil is added: the beating is carried on for three days successively; and as the evaporation in that hot climate is considerable, the cement is kept at the proper degree of softness by the alternate addition of very small quantities of water and oil. The cement being completed, is applied in the usual manner, and speedily acquires a stony hardness. The last species of maltha that we shall mention is the celebrated chunam of India, where it has been used from time immemorial. The method in which it is prepared at Madras is as follows.

Take 15 bushels of pit sand, and 15 bushels of stone lime, slack the latter with water, and when it has fallen to powder, mix the two ingredients together, and let them remain untouched for three days. In the mean time dissolve 20 lbs. of molasses in water, boil a peck of gramm (a kind of pea) to a jelly; boil a peck of mirabolams also to a jelly, mix the three liquors and incorporate part of the mixture very accurately with the lime and sand, so as to make a very fluid cement: some short tow is now to be well beaten into it, and it is then fit for use. The bricks are to be bedded in as thin a layer as possible of this mortar, and when the workmen leave off, though but for an hour, the part where they recommence working is to be well moistened with some of the above liquor before the application of any fresh mortar. When this is used for stucco, the whites of four or five eggs, 4 oz. of butter, or sesamum oil, and a pint of buttermilk, are to be ground up with every half bushel of cement, and the mixture is to be applied immediately.

It is to be regretted that no experiments have as yet been instituted, to ascertain the cause of the induration of calcareous cements: it is obviously not owing to the absorption of carbonic acid, because in numerous instances the cement hardens long before the lime is saturated: in the different kinds of maltha the lime combines with the albumen, mucilage, and oil, with which it is in contact, and in all probability takes up little or no carbonic acid; and if it is true that the lime in old mortar cannot, by burning, be reconverted into quicklime, it may reasonably be questioned whether, even in the simple calcareous cements, carbonic acid acts so important a part as is usually attributed to it.

CERUSE, or *White Lead*, is a white oxyd of this metal prepared by the vapour of vinegar. See Lead.

CHALCEDONY. Of this mineral there are two subspecies.

1. Subspecies. Common Chalcedony.

The colour of chalcedony is bluish grey, passing into milk-white and smalt-blue; greenish grey, passing into apple and olive green; and yellowish grey, passing into wax and ochre-yellow, yellowish and blackish brown, and brownish black. Two or more of these colours are not unfrequently found in the same specimen, of which one generally forms the basis, while the others are distributed over its surface in dots, clouds, or stripes.

It occurs in geodes and veins in Amygdaloid; also in veins accompanied by quartz, pyrites, &c. in porphyry. It was anciently procured from Chalcedon in lesser Asia, whence its name, but at present it is found principally in Scotland and the adjoining islands, in Cornwall, Iceland, Saxony, Hungary, Piedmont, and various parts of Asiatic Russia.

2d Subspecies, Carnelian.

The usual colour of this mineral is blood-red, whence it passes into flesh-red, reddish-white, milk-white, orange, and

honey-yellow: two or more colours often occur in the same specimen, disposed in zones, stripes, and arborizations.

It is customary among modern mineralogists to place *agates* as an appendage to the species of chalcedony, since it is to this mineral that the former is indebted for its most striking characters, and because the coloured chalcedonies pass imperceptibly into agate.

Agate is a mixture of chalcedony, carnelian, jasper, hornstone, quartz, heliotrope amethyst, and indurated lithomarga, aggregated into binary or more complex combinations.

Agates are found for the most part in nodules in Amygdaloid, and sometimes in Gypsum: near the river Wolga they occur between strata of secondary limestone: and in Siberia certain rocky tracts consist of banks of pudding-stone, of which agate and chalcedony form the principal part.

The most beautiful agates that Europe produces, are those of Oberstein in the Duchy of Deuxponts. Those of Siberia are eminently beautiful, but the most esteemed of all come from Ceylon and other parts of India.

Agate is cut into cameos or seal-stones, is hollowed into snuff-boxes, or sawn into thin plates for inlaying tables, and is applied to other ornamental purposes. The commoner kinds are made into mortars for the enameller and chemist, as from their hardness they are not liable to be materially abraded by pulverizing the hardest glass and stones in them. The coarsest fragments that are applicable to no other use are formed into the white gunflints, which are harder than common flint, and not so brittle.

CHALK. See Lime.

CHARCOAL, or *Carbon* of the French chemists, a sort of artificial coal, or fuel, consisting of half-burnt wood. It is chiefly used, where a clear and strong fire without smoke is required; for the humidity of the wood is dissipated by the fire in which it was prepared.

The art of making charcoal is very ancient; for even Solomon (Proverbs xxvi. 21.), distinguishes that kind of fuel from common fire-wood. Among the Romans, it was held in great estimation, and Æmilius Scaurus, the conqueror of the Ligurians, was a charcoal-merchant. Pliny describes the piles of wood erected by the manufacturers of this article, and observes that the blocks ought to be placed in a pyramidal form, coated with clay, and a hole left on the top for conducting the smoke, when the wood is set on fire. Thus, it would be unnecessary to describe the process, for those who employ themselves in the preparation of this article.

Charcoal may be preserved to an indefinite length of time, and in the ancient tombs of northern nations, entire pieces are frequently discovered. It is, therefore, deserving the attention of those, who wish to preserve valuable records from the "destructive tooth of time;" for there yet exists, according to Dodart, charcoal made of corn (probably in the days of Cæsar) which is in so complete a state, that the wheat may be distinguished from the rye.

This substance is not soluble in any of the acids, but may be dissolved in considerable quantities, by plunging it into a solution of the liver of sulphur, to which it imparts a green colour. Melted with colourless frits, or glasses, it gives a pale, dark, yellow, reddish, brownish, or blackish colour, accordingly as the inflammable matter is in greater or less proportion. Fresh charcoal made of wood strongly attracts the air, and will absorb it for a considerable time; but Dr. Priestley uniformly observed, that, after submitting it to distillation, the expelled air was less pure than that of the atmosphere, and part of it was *fixed air*. Hence it may occasionally be employed in a *dry* and *powdered* state, for damp and foul habitations. Lastly, Dr. Priestley has discovered that several of the metals, such as copper, iron, silver, &c. may be converted into charcoal, by passing the steam of either spirit of wine or turpentine, over them when red hot; and this, by way of distinction, he calls the *charcoal of metals*. As charcoal has been separated from the purest spirit of wine in the process of making ether, M. Lavoisier is of opinion, that it is one of the constituent parts, or elements, of that volatile liquid.

Uses.—Besides the great advantage which charcoal affords to the artist and manufacturer, it has lately been employed with considerable success, 1. In correcting the burnt or empyreumatic taste of ardent spirits; 2. In depriving rancid oil of its disagreeable flavour; and 3. In restoring putrid meat. For these useful purposes, however, it is fit only when kept in close vessels immediately after it has been prepared, so that it may absorb no acidity, or fixed air, from the common atmosphere. When employed in the two first-mentioned cases, it should be previously reduced to powder, a very large quantity of which is required for the rectification of distilled liquor; but a smaller proportion, for purifying animal or vegetable oil, so that even the common train-oil may be rendered fit for being burnt in chamber-

lamps. Several manufactories of this description have lately been established in the vicinity of London, of which we shall only mention that carried on by Mr. Joshua Collier, of Southwark.

From the great attraction which charcoal possesses for any kind of oily matter, or for that invisible something, formerly called *phlogiston*, it is excellently adapted to become an extensively useful agent in various branches of the arts. We shall therefore communicate the following abstract of the late discoveries made on this subject, chiefly by Prof. Lowitz, of St. Petersburgh, [in 1786.] This philosopher found, that charcoal rendered the crystals of tartar very white and pure, when employed in preparing them; that the marine and nitrous acids are decomposed by being distilled upon it; that the red juices of vegetable fruits are deprived of their colour, without losing part of their acidity; that brown, rancid oils are rendered sweet and clear, by agitating them for some days with charcoal in powder; that it changes the smell of putrid vegetables to that of a pure volatile alkali, and produces the same effect on fresh meat. By boiling coals in powder, with honey, the pure saccharine parts of the latter are said to be separated, and the honey to become a well-tasted sugar. Vinegar concentrated by freezing, and distilled from a large portion of powdered coal, is extremely strong, pure, and fragrant. Corn-spirit, merely shaken with coal, loses its bad flavour; and, if honey be added, it becomes a sweet and pleasant liquor. Even the tainted flavour of ardent spirits, when impregnated with any vegetable oils, may in a similar manner be destroyed; and, if the spirit be distilled, the residuum is said not to be brown; so that no inconvenience will arise from carrying the distillation too far. These effects were produced by every kind of coal, whether fossil or charred vegetable substances; though the latter appear to us, in many respects, preferable to coke.

Charcoal is of the greatest utility in purifying water on ship-board. The most offensive water may be rendered perfectly sweet by merely filtering it through sponge, maple, hickory, or oak charcoal, and sand. A simple apparatus for performing this operation, shall be described under the article FILTER. Casks charred on the inside will preserve water a long time sweet; but it would seem to be a preferable mode (where practicable), to permit the water to undergo the usual fermentation, and then draw it off into the charred casks.

There are considerable differences in the coals of various vegetables, with respect to their habitude to fire: the very light coals of linen, cotton, some fungi, &c. quickly catch fire from a spark, and soon consume: the more dense ones of woods, and roots, are set on fire with greater difficulty, and burn more slowly; the coals of the black berry-bearing alder, of the hazel, willow, lime-tree, and maple, are the most proper for making gunpowder, and other pyrotechnical compositions. For the reduction of metallic calces, those of heavier wood, as oak and beech, are preferable; because these appear to contain a larger proportion of the inflammable principle, and perhaps in a more fixed state. Considered as common fuel, those of the heavy woods afford the greatest heat, and require a most abundant supply of air, in order to keep them burning; on the contrary, the coals of the light woods retain a glowing heat, till they are consumed, without a strong draught of air: the bark usually crackles while burning, which is seldom the case with the coal of the wood itself.

Charcoal is likewise of considerable service to different artists, for polishing brass and copper-plates, after they have been rubbed clean with powdered pumice stone. Horn plates may be polished in a similar manner, and a gloss afterwards given them with tripoli. Coals of different substances are also used as pigments; hence the bone and ivory-black of the shops. Most paints of this kind are not only incorruptible, but also possess the advantage of full colour, and work freely in all the forms, where powdery pigments are employed; but they ought to be carefully prepared, by thoroughly burning the substance in a close vessel, and afterwards reducing the coal to a fine powder. In drawing outlines, the artist avails himself of pieces of charcoal, the marks of which may be easily rubbed out. For this purpose, the smaller branches of a tree, such as the willow and vine, are usually preferred; and which, after being freed from the bark and pith, afford the best drawing pencils. Dr. Lewis remarks, that the shells and stones of fruit yielded coals, so hard that they would with difficulty mark on paper, while those of the kernels of fruit were very soft and mellow. All these experiments must be conducted in proper vessels, closely covered (the barrels of old guns, or pistols, may occasionally serve as substitutes). The Doctor levigated various coals into fine powder, mixed them with gum-water and oil, and applied them as paints, diluted with different degrees of white. When laid on thick, they all appeared of a strong, full black;

nor could it be discerned, that one was of a finer colour than another; but those diluted with white, or spread thin, had a blueish cast.—Horns, and the bones, both of fish and land animals, produced coals more glossy, and of a deeper colour, than vegetables; and which in general were so hard that paper could scarcely be stained with them; but silk, wool, leather, blood, and the fleshy parts of animals, yielded soft coals. Some of these remarkably differed from others, in colour; that of ivory being superior to all, and doubtless the finest of black produced by fire.

In agriculture, charcoal has, in many parts of France and the Netherlands, been substituted for turf-ashes, as a manure.

The utility of charcoal (oxyd of carbon) as a manure, has often been mentioned by practical writers, but was not much regarded until Mr. Kirwan called the attention of chemists to the subject. Mr. Deane says, that he had long observed the great fertility of lands near to where coal kilns were burnt, and quotes the *Complete Farmer* for a confirmation of the facts. Carbon is now known to be one of the most universal materials of nature. The whole atmosphere contains always a quantity of it in the form of carbonic acid. It also exists in *lime-stone* in the same form, and in the black earth left by the decomposition of vegetable and animal bodies. Morasses too, consist principally of the carbonic recrements of vegetable matter.

By what means this solid substance is rendered fluid, so as to be capable of entering the fine mouths of vegetable absorbents, is not yet decided by chemists. It is, however, sufficient for the practical man to be assured of the fact, that he will derive much benefit from strewing charcoal on his land.

Charcoal prepared from maple wood, and finely powdered, makes a simple, efficacious, and safe tooth-powder, and ought to be preferred to any other. The way to prepare charcoal in the nicest manner, is to cut the wood in small billets, and distil them in an iron cylinder, having a tube fixed to one end, to permit the free exit of the smoke and water, which are retained in the common process of charring wood, and tend to render the product impure, and of a disagreeable taste. When no more smoke or water escape from the tube, put out the fire, and close the mouth with clay until the cylinder cools, or the pieces of wood may be put in a pot not closely covered, and surrounded with live coals, until all smoke from the pot shall cease. Then remove the coals, and closely lute the cover with clay until the pot cools—then powder the charcoal.

Meat which has been kept too long in summer, may be deprived of its bad smell by putting it in water, and throwing into the pot, when beginning to boil, a shovel full of live coals, destitute of smoke; after a few minutes have elapsed, the water must be changed, when the operation, if necessary, may be repeated.

It is probable that meat surrounded by fresh charcoal would keep for months.

Mr. Mushet of the Carron Iron works, observes, that charcoal is preferable to coke for the manufactory of iron, owing to the superior quantity of unalloyed carbon it affords to the iron. A determinate quantity of charcoal by measure, will smelt and convey principle to three times the quantity of iron, that can be done by the same measure of pit coal. In the refinery way, it is peculiarly preferable.

An engineer of considerable merit states, that in this respect it is superior to coke in the proportion of 7 to 12.

Charcoal is one of the greatest non-conductors of heat. This quality renders it applicable to a variety of economical purposes.

Finally, the uses of charcoal are very extensive and important. Its greatest consumption is as an article of fuel both for domestic purposes and in the working of metals. It is of indispensable necessity in the laboratory both as a fuel and an ingredient in all kinds of reducing fluxes. It is employed to convert iron into steel by cementation. It is an essential constituent part of gunpowder, and is the basis of almost all black paints and varnishes. It is employed by mathematical instrument-makers and others in polishing brass and copper, and is used in many cases with great advantage as a simple and efficacious clarifier and purifier.

From a late account given by Dr. Metzler, an eminent physician in Germany, we learn the following extraordinary fact: The corpse of a person that had been murdered twelve days, was brought before a coroner's inquest; and, contrary to the expectation of the court, there was not the least mark of putrefaction, nor any offensive smell perceptible. On opening the intestines of the abdomen, they were found in an unusually dry state. The cause of this phenomenon was soon discovered; for it appeared in the course of examination, that the body had been kept for the whole time buried in dry coals, coarsely pounded, at least twelve inches deep. It was still more remarkable, "that the cartilaginous parts, especially those of the breast, had acquired a degree of softness,

resembling that of butter."—We submit the application of this singular property to the discernment of our readers.

With regard to the treatment of persons suffocated by the deleterious vapour of charcoal, we shall in this place only observe, that a body in that unfortunate situation, ought to be without delay exposed to the strongest draught of cold air; all the garments loosened; volatile spirits held to the nostrils; the body well rubbed either with vinegar, or with a diluted spirit of sal ammoniac; the face should be turned towards the ground, and the head, breast, back, &c. either washed with, or the whole body suddenly plunged into cold water; then dried, and again washed with vinegar; stimulating clysters repeatedly administered, and venesection performed at the jugular vein, or, for want of medical assistance, a number of leeches applied to the neck and temples, if the pulse is high, but not otherwise.

CHEESE, a species of solid food, prepared from curdled milk cleared of the whey, and afterwards dried for use. As this article constitutes a material part of domestic consumption, we find in almost every country, one or more places celebrated for the superior quality of their cheese. Hence, we propose to enumerate the principal sorts of manufacture, both at home and abroad; introducing also an account of the mode in which they are prepared.

1. *Stilton Cheese* is produced in the town of that name, in the county of Huntingdon; and from its peculiar richness, and flavour, is sometimes called *English Parmesan*. The process of making it is as follows: the night's cream is put to the morning's milk, with the rennet; when the curd *is come*, it is not broken, as is usually done with other cheese, but taken out whole, and put into a sieve, in order to drain gradually. While draining, it is pressed till it becomes firm and dry; when it is placed in a wooden hoop, or box, made to fit it, as it is so extremely rich, that without this precaution, it would be apt to separate. It is afterwards kept on dry boards, and turned daily, with cloth binders round it, which are tightened as occasion requires. After being taken out of the hoop, the cheese is closely bound with cloths, which are changed every day, till it acquires sufficient firmness to support itself: when these cloths are removed, each cheese is rubbed over daily, for two or three months, with a brush; and, if the weather be damp, or moist, twice a day: the tops and bottoms are treated in a similar manner every day, even before the cloths are taken off.

Stilton cheese is sometimes made in nets, resembling cabbage nets; but these are neither so good, nor so richly flavoured, as those prepared in the manner before described.

Although the Stilton farmers are in much repute for their cleanliness, they take but little pains with the rennet; as they, in general, cut small pieces from the *vell* or *maw*, that are put into the milk; and, being gently agitated with the hand, break, or turn it, so that the curd is easily obtained. We venture, however, to say, that their valuable cheese might be improved, and few broken ones occur, if they would prepare the rennet in the manner adopted in the west of England; namely, by keeping the vell, *maw*, or *rennet-bag* (as it is differently called), perfectly sweet and fresh; for, if it be in the least degree tainted, the cheese will never acquire a fine flavour. When the vell, or maw, is fit for the purpose, a strong solution of salt should be made, with two quarts of soft, sweet water, into which are to be introduced sweet-briar, rose leaves and flowers, cinnamon, mace, cloves, and, in short, almost every kind of spice and aromatics, that can be procured. The whole must boil gently, till the liquor is reduced to three pints, and care should be taken that it be not smoked. The spices should next be strained clean, and the liquid, when milk warm, poured upon the vell, or maw. A lemon may then be sliced into it, and the whole stand at rest for a day or two; after which it should be again strained, and bottled. Thus, if well corked, it will keep good for twelve months, or longer, possess a fine aromatic odour, and impart an agreeable flavour to the cheese.

II. *Cheshire Cheese*, is prepared in the following way: The evening's milk is not touched till the next morning, when the cream is taken off, and put to warm in a brass pan, heated with boiling water: one-third part of that milk is heated in a similar manner. The cows being milked early in the morning, the new milk, and that of the preceding night, thus prepared, are poured into a large tub, together with the cream. A piece of rennet, kept in luke-warm water, since the preceding evening, is put into the tub, in order to coagulate the milk; with which, if the cheese is intended to be coloured, a small quantity of *arnotto* (or an infusion of marigolds, or carrots), is rubbed fine and mixed; the whole is stirred together, and, being covered up warm, allowed to stand about half an hour, or till it is coagulated; when it is first turned over with a bowl, to separate the whey from the

curds, and broken soon after into very small particles: the whey being separated, by standing some time, is taken from the curd, which sinks to the bottom, and is then collected into a part of the tub, provided with a slip, or loose board, to cross the diameter of the bottom, for the sole purpose of effecting this separation: on which a board is placed weighing from 60, to 120 pounds, in order to press out the whey. As soon as it acquires a greater degree of solidity, it is cut into slices, and turned over several times, to extract all the whey, and again pressed with weights: these operations may consume about an hour and a half. It is then taken from the tub, and broken very small by the hand, salted, and put into a cheese vat, the depth of which is enlarged by a tin hoop fitted to the top. The side is then strongly pressed, both by hand, and with a board at the top, well weighted; and wooden skewers are placed round the cheese, at the centre, which are frequently drawn out. It is then shifted out of the vat, a cloth being previously put on the top of it, and reversed on the cloth into another vat, or again into the same, if well scalded, before the cheese be returned to it. The top or upper part, is next broken by the hand, down to the middle, salted, pressed, weighed, and skewered, as before, till all the whey is extracted. This being done, the cheese is again reversed into another vat, likewise warmed, with a cloth under it, and a tin hoop, or binder, put round the upper edge of the cheese, and within the sides of the vat; the former being previously inclosed in a cloth, and its edges put within the vessel. These various operations are performed from about seven o'clock in the morning till one at noon. The pressing of the cheese requires about eight hours more, as it must be twice turned in the vat, round which thin wire skewers are passed and shifted occasionally. The next morning it ought to be turned, and pressed again, as likewise at night, and on the succeeding day; about the middle of which it is removed to the salting room, where the outside is salted, and a cloth binder tied round it. After this process, the cheese is turned twice daily, for six or seven days; then left two or three days to dry, during which time, it is once turned, and cleaned every day; and at length deposited in the common cheese-room, on a boarded floor, covered with straw, where it is turned daily, till it acquires sufficient hardness. The room should be of a moderate warmth, but no wind, or draught of air, must be permitted to enter, as this generally cracks the cheese. The outsides, or rinds of them, are sometimes rubbed with butter, or oil, in order to give them a coat.

III. *Gloucester Cheese*, is made of milk immediately from the cow; but which, in summer, is thought too hot, and is, therefore, lowered to the requisite degree of heat, before the rennet is added; by pouring in skim-milk, or, if that will not answer, by the addition of water. As soon as the curd "is come," it is broken with a double cheese knife, and also with the hand, in order to clear it from the whey, which is laded off. The curd, being thus freed from the principal part of the whey, is put into vats, which are set in the press for ten or fifteen minutes, in order to extract all the remaining liquid. It is then turned out of the vats into the cheese tubs again; broken small, and scalded with a pailful of water, lowered with whey, about three parts of water to one of whey; and the whole is briskly agitated, the curd and water being equally mixed together. After having stood a few minutes, to let the curd subside, the liquor is poured off; and the former collected into a vat, the surface of which is, when about half full, sprinkled with a little salt, that is worked in among the curd. The vat is then filled up, and the whole mass turned two or three times in it, the edges being pared, and the middle rounded up at each turning. At length, the curd is put into a cloth, and placed in the press, whence it is carried to the shelves, and turned, generally, once a day, till it has acquired a sufficient degree of compactness, to enable it to undergo the operation of washing.

IV. *Wiltshire Cheese.* The milk which produces this cheese is *run*, as it comes from the cow, or as it happens to be *lowered*, by the small quantity of skim-milk mixed with it. The curd is first broken with the hand and dish, care being taken, in first crushing the curd, to let the whey run off gradually, to prevent its carrying away with it the "*fat*" of the cowl. For thin cheese, the curd is not broken so fine as in Gloucestershire; for thick cheese, it is crushed still finer; and, for what is called *loaves*, it is, in a manner, reduced to atoms. The whey is poured off as it rises, and the curd pressed down. The mass of curd is then *pared down*, three or four times over, in slices about an inch thick, in order to extract all the whey from it, pressed, and scalded in a similar manner to the Gloucester cheese. After separating the whey, the curd is, in some dairies, rebroken, and salted in the *cowl*; while, in others, it is taken warm out of the liquor, and

salted in the vat: thin cheese being placed, with a small handful of salt, in one layer; thick ones, with two small handfuls, in two layers; *loaves*, with two handfuls, in three or four layers; the salt being spread, and rubbed uniformly among the curd. Wiltshire cheese is commonly salted twice in the press, where it remains in proportion to its thickness; thin cheese three or four *meals;* thick ones, four or five; and *loaves*, five or six.

Wiltshire cheese is esteemed among the best kinds that are made in England.

V. *Cottenham Cheese.* The superiority of this cheese, both in delicacy and flavour, is not ascribed to any particular management of the dairies, but solely to the fragrant nature of the herbage on the commons.

VI. *Suffolk*, or *Skim-Cheese.* The curd used in making this cheese, is "broken up," in the whey, which is poured off, as soon as the former has subsided; the remainder, with the curd, being thrown into a coarse strainer, and exposed for cooling, is then pressed as tightly as possible; after which, it is put into a vat, and set in a press, for a few minutes, to discharge the remaining whey. When all the liquid part is drained off, the curd is taken out, again broken as finely as possible, salted, and returned to the press. In some large dairies, mills are employed for breaking the curd. This kind of cheese is much used at sea, as being less liable to be affected by the heat of warm climates, than the others.

Dr. Anderson remarks, that these cheeses are remarkable for "a horny hardness and indigestible quality."

VII. *Chedder Cheese*, is held in high estimation; but its goodness is attributed chiefly to the land on which the cows feed; as the method of making it is similar to that pursued throughout Somersetshire, and the adjoining counties.

VIII *Lincolnshire Cheese.* By adding the cream of one meal's milk, to that which comes immediately from the cow, excellent cream cheese is made in that county. It is gently pressed two or three times, and turned for a few days, previously to its being sent to market. This cheese is usually eaten whilst new.

Bath Cheese—Take 6 quarts of lukewarm new milk, to which should be added two quarts of spring water, and one large table-spoonful of rennet: when the coagulation is completed, which generally takes place in half an hour, the curd must be broken to pieces; then suffered to settle; and, after straining the whey, it should be put into square vats. In the course of an hour, it will be requisite to turn the curd; which operation must be repeated after some hours, or at night; and continued twice every day, till the cheese be fit for the table.

Hafod Cheese—Let 30 gallons of new milk, and 3 gallons of sweet cream, be mixed with the juice expressed from one peck of picked marigold flowers. One-fourth of a pint of sack or canary wine and a sufficient quantity of rennet contained in a bag, together with cloves and mace, in order to coagulate the milk. When the curd is formed, it must be broken very small; and after carefully expressing the whey, it ought to be put into a cheese vat, covered with a wet cloth, and pressed by the hands. A pound of newly made butter is then to be incorporated with such a quantity of salt as may be required to season the cheese; and after combining these ingredients with the curd, the whole must again be put into the vat, and treated in the manner above described. Now, the cheese must be submitted to the action of the press; the wet cloths be changed for dry ones, every four hours; and, after having been thus squeezed for 24 hours, it should be placed beneath a smaller weight, and pressed for one week; during which it ought to be turned every day: at the expiration of that period, it must be removed to a dry place, and shifted every other day, till it be ready for use.

Hafod Toasted Cheese, is prepared by warming new milk above the natural temperature; after which the rennet is added. As soon as the curd is *come*, it must be completely drained of the whey, and afterwards scalded with this liquor. The curd is now to be pressed in the cheese mould, in order to render it as dry as its nature will admit; when it is to be broken into small pieces by the hand, and seasoned with a proper quantity of salt. Now it is again submitted to the press, and treated in the usual manner. This process, though more simple than that pursued in Gloucestershire, produces a toasting cheese, little inferior to that prepared in the latter county.

Having thus given an account of the principal sorts of cheese produced in England, we shall likewise enumerate some of the most celebrated kinds prepared on the continent.

1. The *Parmesan Cheese* is made of the evening's milk, after having been skimmed in the morning, and at noon, and mixed with that of the morning, which has likewise been previously skimmed at noon. The whole is poured into a copper

cauldron, resembling an inverted bell, and suspended on the arm of a lever, so as to be moved off and on the fire at pleasure. In this the milk is gradually heated to the temperature of about 120 degrees, when it is removed from the fire. As soon as it has subsided, the rennet, in a small bag, is steeped in it; and, being occasionally squeezed, a sufficient quantity of it soon passes into the milk, which is then well stirred, and left to coagulate. In the course of an hour, the coagulation is completed, when the milk is again put over the fire, and raised to a temperature of about 145 degrees: and, while it is heating, the whole mass is briskly agitated, till the curd separates in small lumps. Part of the whey is then taken out, and a little saffron added to the remainder, in order to colour it. When the curd is thus broken sufficiently small, nearly the whole of the whey is taken out, and two pailfuls of water poured in, by which the temperature is lowered, so as to enable the dairy-man to collect the former, by passing a cloth beneath it, and gathering it up at the corners. The curd is then pressed into a frame of wood, resembling a peck-measure without a bottom, placed on a solid table, and covered by a round piece of wood, with a great stone at the top. In the course of the night, it cools, assumes a firm consistence, and the whey drains off. The next day, one side is salted, and on the succeeding day the cheese is turned, and the other side rubbed in a similar manner. This operation is continued for about forty days, when the outer crust of the cheese is pared off, the fresh surface is varnished with linseed oil, the convex side coloured red, and the cheese is fit for use.

The climate of Pennsylvania is similar to that of Placentia and Milan, where the cheeses called Parmesan are made: and it is highly probable, if we fail in making cheeses of equal flavour and excellence with the English, that we may rival those of Italy, which have a superior advantage in being found to keep in warm climates, much better than most other cheese.

2. *Green Swiss Cheese*, appears to possess no other peculiarity than that derived from the fragrant powder of the common Meliot, or the *Trifolium Melilotus officin.* L. [a native plant of the United States,] which, however, imparts to it a strong flavour, rather offensive than agreeable to most persons: hence it is not calculated to become a favourite article in this country.

3. *Dutch Cheese* is likewise prepared in the manner generally adopted in Cheshire, with this difference, that the Dutch, instead of rennet, make use of spirit of salt. Hence their cheese not only acquires a sharp saline taste, but is also said to be exempt from the depredations of mites: its rich buttery quality must be ascribed to the luxuriant vegetation in the low countries.

4. *Westphalia Cheese.* M. Hochheimeir, a German author, asserts "that it is preferred in England to the Dutch, Swiss, and even Parmesan cheese." Having had no experience of its taste, we can only give an account of the manner in which it is prepared.

After the cream is removed from the milk, when in a sub-acid state, the latter is placed near a fire, spontaneously to coagulate. The curd is then put into a coarse bag, and loaded with ponderous stones to express the whey: in this dry state, it is rubbed between the hands, and crumbled into an empty, clean milk-vat, where it is suffered to remain from three to eight days, accordingly as the cheese is intended to be strong, or mild. This part of the process is called "skinning," or more properly, *mellowing*; because it undergoes the putrid stage of fermentation, and acquires a coat, or skin, on the top, before it is taken out of the vessel, and kneaded into balls, or cylinders, with the addition of a considerable portion of caraway seed, salt and butter; or occasionally, a small quantity of pounded pepper, and cloves. But, if it be too far advanced in the mellowing process, a third part of fresh curds, likewise crumbled into small pieces, is superadded, to prevent, or correct its putrid tendency. In short, the whole mass requires a powerful hand to form a complete union of parts; for it is very apt to corrupt, when imperfectly kneaded. As the pieces, when moulded, are of small size, not exceeding three or four ounces each, in weight, they soon dry in the open air, and are then fit for use. It is, however, necessary to turn and clean them, as well as to shift their places every day upon a board, in order to promote their maturity. After being nearly dry, they are sometimes (for the palate of epicures) suspended in a wood-fire chimney, by means of a net, for several weeks, or months: and both their taste and flavour, are said to be remakably improved, whether kept in a dry air, or subjected to the action of smoke.

5. *Potatoe-Cheese.* There are three varieties of this curious article prepared in Germany: we shall, however, describe only that sort which appears to us the most plausible. The best mealy potatoes are selected, and half-boiled in steam; as, by bursting, their flavour and efficacy

are diminished. When cool, they are peeled, and finely grated, or beat into a pulp with a wooden pestle. Three parts of this soft mass, and two parts of sweet curd, after expressing all its whey, are kneaded together, and allowed to stand two or three days in warm, and four or five days in cold weather. The mixture is then formed into small pieces, like those of Westphalia cheese, and dried in a similar manner.

But, says M. Hochheimer, if you wish to procure a *more delicate potatoe-cheese*, take only one part of potatoes, and three of the curd made of sheep's milk: let the kneaded mass remain three or four days in a vat, to become mellow; then put a stratum of it, one inch high, into a small firkin, strew a few lilac flowers, or caraway and mace, over it; spread a little fresh butter, about the size of a walnut, over these aromatics; then form another layer, repeat the same mode of seasoning the cheese, and proceed in a similar manner to the top of the vessel. When this cheese has been kept for some days in a dry airy place, without being exposed to the sun, it is said to excel in taste the best sort made in Holland; and to possess the additional advantage, that it improves with age, and generates no vermin.

Dr. Anderson thinks that the goodness of cheese depends more upon the particular process adopted in the management, than upon the materials of which the cheese consists. The taste of a Gloucester and that of a Cheshire cheese is very different from each other, though the quality of the milk of which they are made varies very little. The same thing may be said of Stilton and Parmesan cheeses, though their peculiarities are attributed to soil, or pasture, or other circumstances that seem to throw the blame of want of success from off our own shoulders.

The business of cheese making has greatly improved within a few years past in the U. States. The state of Connecticut, and N. York, and the islands near N. Port, Rhode-Island, have deservedly obtained a great character for cheese-making; and an English family near Flemington, New-Jersey, has also justly acquired the highest reputation in the business. Indeed they have clearly evinced, even to the most prejudiced, (upon some of whom an experiment has been made,) that age is only required to render their cheese equal in flavour and richness to those of England. And why should they not be equal, if the same care be used in every part of the process?

As no good cheese can be made without good rennet, it may be well to add the following account of the preparation of that substance, to the mode described by Dr. Willich.

"Dairy women usually preserve the maw, and the curd contained in it, after salting them; and then by steeping this bag and curd, make a rennet to turn their milk for making cheese. But a method which seems to be more simple, and is equally good in every respect, is, to throw away the curd, and after steeping it in pickle, stretch out the maw upon a slender bow inserted into it, which will soon be very dry, and keep well for a long time. Take an inch or two of the maw thus dried, and steep it over night in a few spoonfuls of warm water; which water serves full as well as if the curd had been preserved, for turning the milk. It is said that one inch will serve for the milk of five cows.

An ingenious writer, who has made strict inquiry into this subject recommends the following method of preparing a rennet, which he has found to be better than any other.—"Throw away the natural curd, which is apt to taint, and give the bag a bad smell; then make an artificial curd, or rather butter, of new cream, of sufficient quantity to fill the bag. Add three new laid eggs well beaten, one nutmeg grated fine, or any other good spice: Mix them well together, with three teacups full of fine salt: Fill the rennet bag with this substance: Tie up the mouth: Lay it under a strong brine for three days, turning it over daily. Then hang it up in a cool and dry place for six weeks, and it will be fit for use. When it is used, take, with a spoon out of the bag, a sufficient quantity of this artificial butyrous curd for the cheese you purpose to make: Dissolve it in a small quantity of warm water, and then use it in the same manner as other rennet is mixed with the milk for its coagulation."

Whatever kind of rennet the dairy woman chooses to prepare, she should keep it in mind, that this animal acid is extremely apt to turn rancid and putrify, and take care to apply a sufficient quantity of salt to preserve it in its best state. For it is probable that the rank and putrid taste, which is so often perceived in cheeses made in this country, is owing to a putridity in the rennet." *Deane's N.E.Farmer.*

Preservation of Cheese. Among the various productions of the vegetable kingdom, there are perhaps none better calculated for this purpose, than the following: 1. The leaves of the Yellow Star of Bethlehem. *Ornithogalum luteum*, L. 2. The

Tutsan, or Park-leaves, *Hypericum Androsæmam*, L. and 3. The tender branches of the common birch tree, *Betula alba*, L.—The two first of which, in particular, have from experience, been found to possess considerable antiseptic properties. They ought, however, to be employed only when moderately dry, in which state they should be placed upon, or at the sides of the cheese, in an airy situation. The twigs of the birch are especially useful, in preventing the ravages of mites.

Hard and spoiled cheese may be restored in the following manner: Take four ounces of pearl-ash, pour sweet white wine over it, till the mixture ceases to effervesce. Filtre the solution, dip into it clean linen cloths, cover the cheese with them, and put the whole into a cool place, or dry cellar. Repeat this process every day, at the same time turning the cheese; and, if necessary, continue it for several weeks: thus, the hardest and most insipid cheese has frequently recovered its former flavour.

CHESNUT, or *Castanea*, L. is a species of the *Fagus* or beech-tree, a genus of plants comprising five species. It flourishes on poor gravelly or sandy soils, and will thrive in any but moist or marshy situations.

There is no plant cultivated, that is more valuable than the chesnut; as it grows to a considerable height, and its wood, if kept dry, is extremely durable. It excels the oak in two respects, namely, that it grows faster, and that the "sapparts" of the timber are more firm, and less liable to corruption. Being greatly superior to elm for door jambs, and several other purposes of house carpentry, it is considered as nearly equal to the oak itself; but, on account of its possessing a precarious brittleness, which renders it unsafe for beams, it ought not to be employed in any situation, where an uncertain weight is sometimes to be supported.

All writers agree that the wood of the chesnut is peculiarly excellent for casks, as it neither shrinks, nor changes the taste or colour of the liquor. It is also converted into various articles of furniture, and when stained, may be made to resemble in beauty and colour the finest mahogany: this improvement is effected, by rubbing it over, first with alum water, then laying on with a brush a decoction of logwood-chips; and lastly, a decoction of Brazil-wood. Besides these various uses, to which this tree may be applied, its fruit affords an agreeable addition to our winter dessert. If properly managed, a sweet and nutritious bread may be prepared of it, especially when mixed with a small proportion of wheaten or other flour.

Chesnuts, especially the small esculent sort, form an important article of commerce, in Italy, and in the island of Corsica; which latter alone exports annually such quantities as amount in value to 100,000 crowns. The Germans roast them among embers, and eat them with butter and salt; the French, with lemon-juice and sugar, which agrees better with weak stomachs. This leguminous fruit is also employed in several articles of confectionary; as a substitute for coffee, and in the preparation of chocolate.

This tree is highly valuable for many purposes, and ought to be carefully attended to by the people of this country. The superiority of the timber over most others in durability, is well known; and the nuts are also very profitable. The tree splits easily, and hence is used for fence rails. An old chesnut tree is very brittle, and apt to crack, and therefore should never stand longer than while it is in a growing state. If cut when it squares only six inches it will be most durable, having very little sap in proportion to other trees. The nuts are the usual, and in some places, almost the only food of the common people in Italy, Savoy, and France, not only boiled and roasted, but also in puddings, cakes, and bread.

The tree may be propagated by planting the *nuts* with the *burrs*, in the spring. The best nuts for planting, are such as are brought from Portugal and Spain, or a large fine kind which are sometimes seen in the Philadelphia markets. The direction to plant the nuts in the burrs is given, in consequence of the destruction of them, which a gentleman in New-Jersey (who has wisely planted several acres) lately experienced from field mice. The nuts, if imported, must be brought over in boxes of earth. In setting the nuts, make a drill with a hoe, about 4 inches deep, and six inches distant, with the eye uppermost: then draw the earth over them with a rake, and make a second drill at about a foot distance from the former, proceeding as before, allowing three rows in a bed, with an alley between them three feet broad, for conveniently cleaning the beds. Keep the ground clear of weeds, and in two years remove the trees to a nursery, at a wider distance. In three years afterwards, transplant them into the places where they are intended to stand.

Forsyth gives a number of judicious directions respecting the propagation of chesnut trees, which cannot be well abrid-

ged, but ought to be consulted by every one who may wish to propagate this valuable tree.

2. FAGUS, *Castanea pumila*, Dwarf chesnut tree, or Chinquepin. This seldom rises above eight or twelve feet, otherwise much resembling the chesnut in the appearance of its branches and leaves. Its fruit capsules are small, and generally contain but one conical shaped nut. It grows naturally in a light gravelly soil: when exported, the nuts should be put in sand, when ripe, and sent away immediately, otherwise they loose their vegetating quality.

HORSE-CHESNUT, or *Æsculus*, L. a genus of exotic plants, natives of the East, consisting of four species: the principal of these is the *Hippocastanum*, or Common Horse-Chesnut. It thrives best in rich fat land, but will also flourish on clayey and marley soils.

This tree grows so rapidly that, in the course of a few years, it becomes large enough, in groves and alleys, to afford a good shade during the heat of summer, when it is in full bloom. Its fruit furnishes a grateful food to horses, and has been successfully employed for fattening cattle, the tallow of which it renders uncommonly firm, especially when mixed with ground barley. The milk obtained from cows fed with it, is also said to be richer than that produced by any other aliment. The nuts have likewise been used with advantage in feeding poultry; but they are unwholesome for hogs. There are, besides, various other purposes to which horse-chesnuts may be rendered subservient in the arts and manufactures.

Prof. Beckmann states, that horse-chesnuts yield, by distillation, a spirituous liquor, which, notwithstanding its bitter taste, may frequently serve as a substitute for alcohol.

Prof. Leonhardi observes, in his *Economical Pocket-Book* for 1793 (in German) that the prickly husks of the horse-chesnut may be advantageously employed in tanning leather; and, when burnt to coal, they are said to produce an excellent black water-colour.—Suckow has made experiments with the brown glossy shell of this fruit; from which it appears, that, when bruised and boiled in water, with the addition of a little pot-ash, it makes a saturated dark-brown dye, which imparted to cloth previously dipped in a solution of green vitriol, a yellow brown, and to that prepared in alum-water, a faint red-brown colour. According to Dambourney, both the branches and leaves communicate a good brown in dyeing.

The wood of the horse-chesnut is, in every respect, equal to that of the common chesnut; and, as the former thrives luxuriantly in coppices, it deserves to be more generally cultivated, with a view of raising timber for building.

In medicine, the bark has been found of eminent service in intermittent fevers, and is often substituted in Russia for the Peruvian bark.

CHROME. An acidifiable metal, first discovered in the red ore of Siberia by Vauquelin in 1797, and so named from the beautiful colours it affords. In this ore it exists in the acid state, forming chromat of lead: chromat of alumine is the colouring matter of the spinel ruby; as the green oxide of chrome is of the Peruvian emerald: and its green oxide is united with lead in the green crystals commonly found with the red lead ore of Siberia. Besides these it has been found in the stones called meteoric by Laugier and Thenard, and combined with iron in an ore dug near Toulon; and also in some districts of the United States.

If the red lead ore be treated with muriatic acid it will be totally dissolved, forming a fine deep red solution. On evaporating the liquor the muriat of lead will fall to the bottom, till the supernatant liquor contains only the oxide of chrome, which gives it a fine green colour, and may be obtained by further evaporation.

Gmelin precipitated the green oxide from its solution in muriatic acid by means of zinc, prussic acid, sulphat of potash, carbonat of potash, and potash alone. The latter threw it down of a mountain blue colour; and this precipitate fused with saline substances into a green mass. As it is very soluble in saline fluxes, he found it difficult to fuse into a metallic button by their means, without precipitating it, while in fusion by means of zinc. The button thus obtained, when fused with borax, rendered it green. This metal has recently been found in considerable quantities in Pennsylvania and Maryland. *Annales de Chimie.—Philos.-Mag.—Fourcoy.*

CHROMIC-ACID. This acid is but lately known, and has only been examined in small quantities by Vauquelin, who first discovered it, and by count Mussin Puschkin; yet we are better acquainted with it, than with the metal that forms its basis. However, as the chromat of iron has lately been found in abundance in the department of Var, in France, we may expect its properties to be more amply investigated, and applied with advantage in the arts, as the chromats of lead and iron are of excellent use in painting and enamelling.

It was extracted from the red lead ore

of Siberia, by treating this ore with carbonat of potash, and separating the alkali by means of a more powerful acid. In this state it is a red or orange-coloured powder, of a peculiar rough metallic taste, which is more sensible in it than in any other metallic acid.

It readily unites with alkalies, and is the only acid that has the property of colouring its salts; whence the name of chromic has been given to it. If two parts of the red lead ore of Siberia in fine powder be boiled with one of an alkali saturated with carbonic acid, in forty parts of water, a carbonat of lead will be precipitated, and the chromat remain dissolved. The solutions are of a lemon colour, and afford crystals of a somewhat deeper hue. Those of chromat of ammonia are in yellow laminæ, having the metallic lustre of gold.

The chromat of barytes is very little soluble, and that of lime still less. They both afford a pale yellow; and when heated give out oxigen gas, as do the alkaline chromats.

If the chromic acid be mixed with filings of tin and the muriatic acid, it becomes at first yellowish brown, and afterward assumes a blueish green colour, which preserves the same shade after desiccation. With a solution of nitrat of mercury it gives a precipitate of a dark cinnabar colour. With a solution of nitrat of silver it gives a precipitate, which, the moment it is formed, appears of a beautiful carmine colour, but becomes purple by exposure to the light.

When melted with borax, or glass, or acid of phosphorus, it communicates to it a beautiful emerald green colour.

CHURN a vessel in which butter, by long and violent agitation, is separated from the serous part of milk. The inferiority of the churns in common use, has induced several ingenious mechanics to exert their skill in contriving others, that would render the process of making butter less tedious and expensive. These are very numerous, and the most approved being in general use, makes a description of them unnecessary. We shall therefore only observe that, if a pump-churn be employed, it may be plunged a foot deep in a tub of cold water, and remain there during the whole time of churning; which will harden the butter in a considerable degree. This operation, as we have before observed, may be much facilitated, by pouring into the churn a small quantity of distilled vinegar, which will produce butter in the course of one hour. Those who make use of a pump-churn, should endeavour to keep up a regular motion of the machine; and by no means admit any person to assist them unless from absolute necessity: for, if the churning be irregularly performed, the butter will in winter *go back*; and, if the agitation be more quick and violent in summer, it will cause the butter to ferment, and thus to acquire a very disagreeable flavour. Where there are many cows, a barrel-churn is preferred; but unless it is kept very clean, the bad effects of it will be soon discovered in the butter. Particular care should also be taken, to place it, in a proper temperature, according to the change of the season; that is, to fix it in a warmer situation in the winter; and, in the summer, to expose it to a free current of air.

CINNABAR, see MERCURY.

CISTERNS are vessels employed for the reception of rain, or other water, either under ground, such as those of navigable canals, &c. or above ground, for domestic and other purposes. In this place we shall only treat of the latter.

As the water collected in leaden cisterns is apt to corrupt, either by stagnating for several days, when the pipes happen to be obstructed, or by the deposition of feculent matter, as well as the incrustation formed in such vessels, it follows that they ought to be frequently cleansed of the copious sediment they contain. This attention is the more necessary, as *lead* is a metal liable to be dissolved by acids; and, in that state, proves a slow, but fatal poison. Although the acidity contained in stagnant water, which has, in its course, been impregnated with animal and vegetable particles, cannot be very considerable, yet it will be more safe, and prudent, to prevent the formation of such acids, by an early attention to the purity of the water. See FILTRATION. For an excellent water cement, see CEMENT.

The deeper cisterns are, the better the water will be kept. Where the ground is not so bad as to require a round form, a cube is a good figure: a double cube must be better, as it gains depth and consequently coolness. A cistern of 6 cubic feet, holds 16 hogsheads of 100 gallons each, or 26 hogsheads. A double cube of 5 feet would hold above 18 rum hogsheads of 100 gallons. The pit should be dug exactly by square and plumb. On the face of the pit, lay potters-clay, plasterwise, with a trowel, coat over coat (as it dries and cracks) two or three inches in all. Against this firm even face of plaster raise the brick or stone work. Bed the bottom, three or four inches thick with strong clay, beat to a smooth, even surface. Moisten the clay, and beat it with

switches, or small hoop poles, but with nothing heavy. On this clay-floor, lay a double bed of brick; and, on the margin of this, carry up the side walls half brick thick, laying them in tarras. Cover the cistern over, but leave room to fix a small pump, which must be two feet from the bottom: or a roller or bucket may be used to raise the water.

The above directions are taken from Mr. Bordley's Essays, and will answer where lime cannot be had to make Mr. Hunn's cement, before noted. In many places of Europe, rain-water saved in cisterns is the only water drank. Stolberg says, he drank some in the vicinity of Naples, near three years old, and found it excellent. Mr. Bentham has lately taught us, that water may be kept during the above period perfectly sweet. On the flat coasts of the United States, these rain water cisterns ought to be generally built: for the water from the ground is very bad, and occasions many of the disorders attributed to other causes.

CITRIC ACID. Lemon juice is known universally to be one of the sourest, and at the same time the most agreeable of all the native vegetable liquors. It is prepared simply by squeezing the fruit, and straining through linen or any other loose filter. In Sicily, Italy, Majorca, and many other parts of the Mediterranean, lemon juice forms an important article of commerce. It is procured simply by peeling the fruit, slicing it, and putting it in a large press with a cloth or hair strainer. The juice, which comes out very turbid, is placed for a day in cellars and then strained, and put in jars with narrow necks well cemented up, the top of the juice being generally covered with a little oil, the better to defend it from the action of the air. Many of the presses will squeeze six thousand lemons at once.

Lemon juice is a natural mixture, composed of much water, of insipid vegetable mucilage, of extractive matter, of a slight portion of something that gives an astringent taste, of a little malic acid, and lastly of that peculiar acid, which, from its being contained more copiously in this fruit than in any other, is called the *citric* acid. The proportions of these ingredients must of course vary according to the degree of ripeness, the season, and the like, but on an average according to Proust, 576 grains of the fresh juice lose by evaporation 528 grains, which is the watery part; and of the remaining 48 grains about 30 grains are the pure citric acid and the remainder is chiefly mucilage and extract. On account of these two latter ingredients, lemon-juice sooner or later, according to the temperature, spoils by keeping, becomes mouldy, undergoes an imperfect fermentation, and at last totally loses its acidity, acquiring a flat musty taste.

To prevent this destruction of the acid for which alone this juice is valuable, many methods of preservation have been devised, all of which answer to a certain degree, but none of them perfectly, except that of separating the acid in a crystallized form by means which will be presently mentioned. It should be observed that of the mucilage and the extractive matter, (the two materials which principally contribute to spoiling the juice) the former alone is separable by the ordinary methods of clarification, but the extract adheres to the acid with the greatest obstinacy, and it is this which hinders it from crystallizing when evaporated nearly to dryness.

Lemon-juice is clarified partly by being put for a day or two in a cold cellar, remaining perfectly at rest. Much of the mucilage then subsides, and the clear juice poured off, bottled, and carefully corked, will then keep for a considerable time. It is better if briskly boiled for a minute or two before it is put aside to clarify, but this somewhat impairs the flavour, and gives one that is not agreeable. In some places, oil is poured over it to prevent the action of the air, which has a temporary effect, but after a while the juice beneath becomes muddy, bitter, mouldy, and besides gets a rank taste from the oil. Concentration by freezing is sometimes used with some success. If the mucilage is first separated as much as may be by standing in a *cool* place, and the clear juice then exposed to a cold of from 23° to 26° the watery part alone freezes, and the remaining unfrozen liquor, of course, contains the acid in a condensed state. By continuing to remove the ice, till it begins to grow sour from the acid itself freezing, lemon juice may be concentrated to about one-eighth of its former bulk, and is then clear, intensely sour, and will keep in a cool climate for several years unaltered. Still however the extract entirely remains and part of the mucilage, and therefore in tropical climates even this concentrated juice spoils in no great length of time, besides the capital defect in the utility of the process, that the cold which it requires can never be obtained naturally in the countries where the fruit grows, and at the season in which it is most likely to spoil.

Sometimes certain mixtures are added to lemon-juice to preserve it. Forster

found in Cook's Voyage to the South Pole that the juice mixed with a fifth part of brandy or rum, in well closed casks, kept very well for thirty-two months. Brugnatelli proposes to clarify the juice by alcohol. Fresh lemon juice was mixed with some strong alcohol and bottled. In a few days a slimy mucilage had separated, and the liquor filtered through paper, contained the purified juice with alcohol, which last may be separated by evaporation. But it is obvious that this only very partially clarifies the juice; for the clear liquor, evaporated slowly to dryness, gives no crystals, but only a sour extract. Besides, the expense forbids its being used in the great way. Some persons add sulphuric or some other mineral acid to the juice, partly to preserve and partly to adulterate it. The juice is indeed kept a long time from moulding by this addition, but the adulteration is often a serious inconvenience and loss. Evaporation is certainly the best method of preserving the juice in hot climates in its natural state, that can be practised in the large way. This juice cannot be purified like vinegar by distillation, for, being less volatile than water, it will not rise in vapour with a heat less than will decompose it; but if the fresh juice simply strained be exposed to a very *gentle* heat, the greater part of the water flies off without carrying away any of the acid, and when the liquor has nearly a syrupy consistence (before it acquires a burnt taste,) it is then intensely sour, and will keep in bottles for many years, with very little alteration, and even retaining much of its original flavour. This inspissated juice or *Rob* of Lemons, as it is called, if intended for the table, may be immediately mixed with dry white sugar, which is known to preserve all vegetable matter from corruption, and it will then keep for almost any length of time unimpaired, and is excellent for sea voyages and domestic use. In hot climates the heat of the sun is made to assist considerably in the evaporation.

But the pure citric acid cannot be obtained by such simple methods, but a double process of chemical affinity is required, first, by adding an intermede to separate it from the other parts of the juice, and next to obtain it free from this addition in its crystallized form. This very ingenious process was discovered by Scheele, and has since been followed by all succeeding chemists, with only a slight variation in the proportions and minutiæ of the process. The intermede which this admirable chemist used was lime added in the form of chalk, the same that he had before employed for a similar purpose in preparing the concrete acid of *Tartar*.

The mode he recommends is in a few words the following: Saturate boiling lemon juice with chalk in powder added gradually, till no more effervescence arises. The compound thence arising is a grey insoluble mass, the citrat of lime, which readily settles, leaving the mucilage, extract, and other ingredients of the juice in the supernatant liquor, which is thrown away, and the calcareous precipitate well washed with *cold* water till it is colourless. Then add to the precipitate a quantity of dilute sulphuric acid, diluted with ten times its bulk of water, and equal in weight to the chalk used, and boil for a few minutes. This by stronger affinity unites with the lime, forming a sulphat of lime equally insoluble with the citrat, whilst the citric acid, now set free, remains dissolved in the clear liquor, and by due evaporation may be procured pure, and in large crystals. The sulphuric acid should be a little in excess to engage all the lime, otherwise the acid will not crystallize.

Such is the process of this excellent chemist, but as the preparation of this acid has lately become an object of some importance in manufacture, it may be of advantage to compare the particulars of the process as given by different chemists.

In preparing citric acid in the great way, M. Dizé mentions the following particulars. After the citrat of lime has been decomposed by the sulphuric acid, *cold* water, assisted by stirring, is sufficient to wash out all the citric acid adhering to the sulphat of lime. This is of use both as saving fuel and as less of the calcareous sulphat is dissolved. Much however is still contained in the clear liquor, which, in fact, is a mixture of citric acid with the excess of sulphuric acid, which it is necessary to add, and sulphat of lime held in solution. This liquor may be evaporated at a heat of boiling water. It is of a clear light yellow. As the bulk of liquid diminishes, the sulphat of lime falls down; and it is of use to suspend the evaporation once or twice for some hours, that, by cooling, the whole of the sulphat may be deposited. Towards the end, the liquor becomes blackish, owing to the sulphuric acid becoming concentrated, and acting partly perhaps on the acid itself, and partly, as the author imagines, on a portion of extractive matter, which subsides along with the citrat of lime, and which he thinks it is necessary to destroy in this manner before the citric acid will crystallize. This acid is so very soluble, that the evaporation must be pushed to a

very thick syrupy consistence before the crystals will separate. They are, at first, black and dirty. By re-solution in cold water (of which a small quantity may suffice) by filtration, and a second evaporation, they become yellow and more regular. A third crystallization seems necessary to make them white and pure. As there is much waste in these operations, the foul portion, which will not pass the filter, should be evaporated and treated as before.

Scheele has well remarked (and all other chemists have found the same) that an excess of sulphuric acid is required. M. Dizé supposes the peculiar use of this excess to be to destroy the remaining extractive matter, the existence of which he endeavours to prove by the proportions of ingredients required, and their products. One hundred pounds of the lemon juice he found to require for saturation 6·25 lb. of chalk, and to produce as much as 20 lb of citrat of lime. On the other hand, he found the crystallized citric acid to require its own weight of chalk for saturation, and to produce a quantity of citrat of lime equal to three-fourths of the weight of the two ingredients, the loss being chiefly carbonic acid. Hence he concludes that 100 lb. of fresh juice contains 6·25 lb. of the pure acid, (that is, equal in weight to the chalk required,) and that the citrat of lime thence resulting, if pure, ought to be no more than 9·378 lb. (being three-fourths of the sums of the weight of the chalk, and the supposed quantity of pure acid.) But as it is really 20 lb. even after washing, he supposes this enormous difference to be made up by extractive matter precipitated along with the citrat of lime, and adhering to it. However, the results of the experiments of other chemists do not give this difference, though they agree tolerably in other particulars. M. Dizé does not specify the quantity of crystallized acid actually obtained from a given quantity of juice.

Westrumb saturated 4 lb. of fresh lemon juice, simply strained, with 3 ounces of chalk, and obtained 5 oz. and 1 drachm of citrat of lime; which, decomposed with 23 drams of strong sulphuric acid diluted with about ten times its bulk of water, gave, by due evaporation, 2½ ounces of crystallized acid a little foul, which lost one drachm by a second crystallization.

Professor Proust has examined the same process. The ingredients and products given by those three chemists, reduced to the same proportion, are as follows:

Lemon Juice		Chalk		Citrat of Lime		Citric Acid in crystals		Citric Acid	
100 lb.	requires for saturation	4.25 lb.	and produces by precipitation	7.51lb.	yields by evaporation	4.38 lb.	and contains by estimation	4.74 lb.	*Proust*
——		4.65 —		8.0 —		3.90 —		——	*Westrumb.*
——		6.25 —		20.		——		6.25 —	*Dizé.*
Cryst. Citric A. 6.25		6.25 —		9.375					Do.

To separate the citric acid completely from the lime, by the sulphuric, in the second step of the process, Proust recommends boiling the whole for about five or ten minutes. The difficulty of separating all the sulphat of lime and extract from the disengaged citric acid, and of procuring clear regular crystals has already been mentioned. A little alcohol added towards the end of the first evaporation, and subsidence, for some hours, greatly assists this separation, and the perfection of the crystals

Lemon juice, when imported in this state, is not unfrequently adulterated with some strong and cheaper acid. The sulphuric is most to be suspected. It is detected in the following way; put some of the juice in a glass, and add a solution of acetite of lead. This will produce a copious white sediment in any case; after which add some drops of strong nitric acid. If the juice contained no sulphuric acid, the white precipitate will be redissolved, and the liquor become again clear, the citrat of lead and malat (of which a small portion will also be formed) being readily soluble in nitric acid; but if the juice was mixed with sulphuric acid, the sulphat of lead will remain at the bottom. If this is collected, washed, and dried, the quantity of sulphuric acid may be estimated from the known proportions of this salt.

Vauquelin asserts, that this acid may be obtained by passing oxymuriatic gas through gum arabic, in water, for a considerable time.

The culinary uses of lemon juice are well known. The concrete citric acid may be often substituted for the juice with advantage, where the latter is not conveniently procurable; but it is to be observed, that none of the peculiar flavour of the fruit, so agreeable in the fresh lemon, passes into the solid acid, which is

merely sour, and without any particular astringency.

The use to which this acid has lately been put in manufactures is as a *discharger* of colour in calico-printing: the white figured parts of coloured patterns, prepared with iron colours, being produced with great clearness and effect by this acid. It is not absolutely necessary to crystallize the acid for this purpose, but only to concentrate it. The mineral acids answer equally as dischargers, but when sufficiently strong to do this effectually, they injure the texture of the cotton.

CLARIFICATION, is the separation, by chemical means, of any liquid from substances suspended in it, and rendering it turbid. If a difference can be made between clarification and *filtration*, it is that the latter is effected by mere mechanical means, but the former either by heat or by certain additions, the action of which may be considered as chiefly chemical. A few practical observations belong to both these articles.

The liquors subjected to clarification are almost, without exception, those animal or vegetable juices, in which the matter that renders them turbid, is so nearly of the same specific gravity with the liquor itself, that mere rest will not effect a separation. In these too the liquid is generally rendered thicker than usual, by holding in solution much mucilage, which further entangles the turbid matter, and prevents it from sinking. Hence it is that vinous fermentation has so powerful an effect as a clarifier, (wine being much more limpid than the grape or other fruit juice of which it is made) since this process always implies the destruction of a portion of saccharine mucilage, and the consequent production of a thin limpid spirit.

Coagulating substances are great clarifiers, when mixed with any turbid liquor, the process of coagulation entangling with it all matters merely suspended and not dissolved, and carrying them either to the *top*, in the form of a scum, or to the *bottom*, in the form of a thick sediment, according to circumstances. Thus, to clarify muddy cyder, the liquor is beaten up with a small quantity of fresh bullock's blood, or new milk, and suffered to stand at rest for some hours, after which the liquor above is as clear as water, and almost as colourless, and at the bottom is a thick tough cake, consisting of the coagulated blood, or milk, which has carried down with it all the opaque matter suspended in the liquor. Many other albuminous and gelatinous substances act in the same manner. The effect of white of egg in this way is known to every one. It should be first mixed with the turbid liquor (a syrup for example) without heat and by agitation. Afterwards, on applying less than a boiling heat, the albumen of the egg coagulates, and carries up with it all the opaque particles of the syrup, leaving the rest beautifully clear and limpid. Isinglass also produces a similar effect.

Sometimes clarification takes place in a very unaccountable manner. Thus it is well known that a handful of marl or clay will clarify a large cistern of muddy water, and marl is also used with advantage in clarifying vinous liquors.

Mere heat will often clarify. Thus the expressed juice of cabbage plants is a strong-smelling, green, clammy, muddy liquid. By heating, all the turbid matter separates in the form of a green coagulum, and the liquor that remains is almost as limpid as water.

Clarification may often be detrimental. In many liquid medicines, such as decoctions of medicinal vegetables and the like, the medicinal portion resides chiefly in that part which is merely suspended, and therefore, when separated by any kind of coagulation, the clear liquor is left nearly inert. See FILTRATION. See also WINE.

CLAY. Any natural earthy mixture which possesses plasticity and ductility, when kneaded up with water, is in common language called a *clay*, which term is probably derived from the Latin *glarea* through the medium of the French *glaise*. All mineralogists however, have comprehended within the appellation, not only clays properly so called, but a few other mineral substances nearly allied to some of the clays, and which become plastic by decomposition. Clay, however, is by no means a mineral species strictly speaking, being in most cases, perhaps in all, the result of the decomposition of other minerals. It seems advisable, therefore, to consider the property of plasticity as an essential character, and to exclude from the class of clays all earthy bodies that are destitute of it.

Mineralogists have hitherto arranged all the plastic clays under two species, rather from the economical uses to which they are applied, than according to their external characters, composition or geological situation: the first species is the white infusible *porcelain clay*, and the second contains all the rest, confounded together, under the general appellation, *Potter's clay*. That this mode of arrangement is very defective, will be readily allowed, and the reader, it is hoped, will receive with candour the following attempt at a more scientific classification.

Essential character. *Plastic by intimate mixture with water.*

1. *Porcelain clay.*

Its colour is generally reddish-white, also greyish and yellowish-white: it has no lustre nor transparency. It occurs either friable or compact; stains the fingers; adheres to the tongue; is soft but meagre to the feel: is easily broken. Sp. gr. about 2. 3. It falls to pieces in water, and by kneading becomes ductile, though not in a very great degree. The Cornish porcelain clay certainly originates from the decomposition of feltspar, and contains particles of quartz, mica, and talc, from which it is separated by elutriation. The Chinese kaolin also contains mica, and is probably of the same origin as the Cornish. The same remark may be applied to the French &c. It is, however, by no means certain, that all porcelain clay is derived from feltspar, as it varies considerably in its composition and fusibility; all the kinds indeed are infusible at any temperature less than a white heat, but some, especially the Japanese, are refractory in the most powerful furnaces. The Cornish clay, according to Wedgewood, consists of 60 per cent. alumine, and 40 silex. That from Limoges in France, according to Hassenfratz, contains 62 silex, 19 alumine, 12 magnesia, 7 sulphat of barytes. Another specimen of the same, analysed by Vauquelin, gave 55 silex, 27 alumine, 2 lime, 0. 5 iron, 14 water. A porcelain clay analysed by Rose, gave 52 silex, 47 alumine, 0.33 iron.

2. *Steatitic clay,*

Its colour is a light flesh red passing into cream colour; its texture is minutely foliated; it has a slight, somewhat greasy lustre, and takes a polish from the nail. It stains the fingers, is very friable, and has a smooth unctuous feel. When laid on the tongue, it dissolves into a smooth pulp, without any gritty particles; it is very plastic and has a strong argillaceous odour. It occurs in nodules, in a hard cellular horn-stone, that forms large mountainous masses near Conway in North Wales, and originates from the decomposition of indurated steatite.

3. *Clay from Slate.*

Its colour is ash-grey passing into ochre-yellow: its texture is foliated: it has a smooth unctuous feel, and its siliceous particles are so small as to occasion scarcely any grittiness between the teeth. It occurs in thin beds on the tops of the softer kinds of slate-rock, and, from its imperviousness to water, is always found lining the bottoms of the peat mosses with which this kind of mountains is generally covered; and in these situations it is of a white ash colour, being deprived of its iron and carbon by the acid of the peat. It also occurs, in thicker beds, at the foot of the mountains, but is of a darker colour and less plastic.

4. *Clay from Shale.*

Its colour varies from greyish-blue to bluish black: its texture is foliated: it has a smooth unctuous feel, takes a polish from the nail, is excessively tenacious and ductile, and has but a slight degree of grittiness. When burnt, it acquires more or less of an ochre-red colour: those varieties which are of the deepest red, usually contain, before burning, a portion of sulphuric acid. It is for the most part difficult of fusion. It occurs abundantly in all collieries, and is produced by the spontaneous decomposition of the shale with which the beds of coal are covered. A sandy clay, of a greyer colour, and more refractory nature, is procured from the decomposition of the indurated clay that forms the floor of the coal, and is provincially called clunch. The Sturbridge clay, from which crucibles, glasshouse-pots, &c. are made, is of this kind.

5. *Clay from Trap.*

At the foot of the softer rocks of trap-formation, such as wakke, clay-porphyry, and some varieties of grunstein and hornblende rock, are found beds of clay evidently originating from the gradual disintegration of these by the weather. The colour of this clay is generally brownish grey verging to ochre yellow; it occurs in mass, is of a compact texture, unctuous, tenacious, gritty, and probably is not very infusible.

6. *Marley clay.*

The colour of this is bluish or brownish red: it occurs either compact or foliated: it has a soft unctuous feel, takes a polish by friction with the nail, is very plastic, more or less gritty, though not so much so as the common alluvial clay. It burns to a brick of a buff or deep cream colour, and at a high heat readily enters into fusion. It effervesces strongly with acids, and contains from $\frac{1}{4}$ to $\frac{1}{10}$ of carbonated lime. It originates sometimes from the decomposition of compact argillaceous limestone, but more frequently from the softer slaty varieties, usually called stone marl. It is largely employed as a manure, and where the calcareous part does not exceed 10 or 12 per cent. it is esteemed as a material for bricks.

7. *Clay from metallic veins.*

Its colour is grey verging into bluish, greenish and yellowish, or red. It has a smooth unctuous feel, is very tenacious, often contains sulphuric acid and certain metallic oxyds, which are never observed

in other clays, such as lead, silver, antimony, copper, and bismuth. Is found in metallic veins.

8. *Alluvial clay.*

The circumstances which characterize alluvial clay are the following. It contains a larger proportion of quartzy sand than the preceding; rounded pebbles of various kinds are also imbedded in it; thus showing it to have been carried from its native situation, and mingled in its progress, with a variety of extraneous bodies. At least three kinds of it may be distinguished, viz. Pipe clay, Potter's clay, and Chalky clay.

Pipe clay is of a greyish or yellowish white colour, an earthy fracture and a smooth greasy feel: it adheres pretty strongly to the tongue, is very plastic and tenacious; when burnt, is of a milk-white colour; is difficultly fusible, much more so than porcelain clay, from which it is further distinguished by its superior plasticity and the sand which it contains. It is manufactured into tobacco-pipes, and is the basis of the white or Queen's-ware pottery.

Potter's clay is of a reddish, blueish or greenish colour, has a somewhat fine earthy fracture, and a soft, often greasy feel: it adheres to the tongue and is very plastic. It burns to a hard porous red brick, and in a higher heat runs into a dark coloured flag. When tempered with water, and mixed with sand, it is manufactured into bricks: those varieties that are the most free from pebbles are made into tiles and coarse red pottery.

Chalky clay is of a leaden blue colour, an earthy fracture and a meagre feel: it is plastic, but breaks down by exposure to the weather. It contains a large proportion of sand and rounded pieces of chalk of all sizes up to that of a hazle nut. It effervesces strongly with acids, burns to a red porous brick, and is very fusible. It is used as a manure. The United States abound with a variety of excellent clays, proper for even the finest of wares; and before the revolutionary war, a china manufactory was established in Philadelphia, and some excellent specimens made at it, are still to be found. This clay was brought from *Whiteclay* creek, Delaware; as we have been informed. See AGRICULTURE. BRICK. EARTHS and ALUMINE.

CLOTH-MAKING. See MANUFACTURE OF CLOTH.

CLOVER, a species of trefoil, or *Trifolium*, L. a genus of plants comprising 55 species, of which only 16 are indigenous in England: of these the following are the principal.

1. The *pratense*, or common [red] clover, which is frequently found in meadows and pastures. This species thrives best on a firm heavy soil, and is raised from seed, which is usually sown between the months of February and April in the proportion of ten or fifteen pounds per acre. If it be often sown on the same land, the crop will fail; it should therefore be changed for trefoil or lucerne.

The common clover is in flower from May to September, and produces seeds which are known to be ripe by the stalks and heads changing their colour. Cattle, sheep, and pigs are exceedingly fond of this species, and frequently eat of it so eagerly as to become *hoven* or *blown*. That disorder, however, may be prevented by constantly moving them about the field, when turned in, so that the first ball may sink into their maw before the next be deposited. Or, if cattle be turned into clover belly-deep, they will, it is said, receive no injury by eating too freely of it; as it is pernicious only in its earlier state.—Should they, nevertheless, be attacked with that dangerous swelling, they may be relieved by adopting the remedies pointed out under the article CATTLE.

In Sweden, the heads are employed for dyeing wool of a green colour; and if mixed with alum, they yield a light, if with copperas, a dark green colour.

2. The *medium*, or red perennial clover, which is found in pastures, hedges, and on the sides of woods. It thrives on a rich soil, whether clay or gravel, and will even grow upon a moor, if properly cultivated.

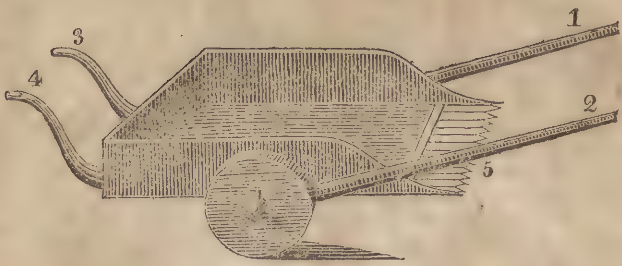
When red clover is intended for seed, the ground ought to be carefully cleared of weeds, that the seed may be preserved pure. It is collected both from the first and second crop, but principally from the former. When one half of the field has changed its colour, by the drying of the *clover heads*, the reaping of them may then be commenced. In America, this is effected by two implements, [which are described in the trans. of N. Y. Agric. Soc. by Mr. L'Hommedieu, and were invented in Brookhaven, Suffolk County, New York,] and for ingenuity and simplicity of construction, deserve to be greatly recommended: we have therefore subjoined the following representations:

Dimensions.

1, 2, The shafts, 4 feet 4 inches long, and 3 feet asunder.

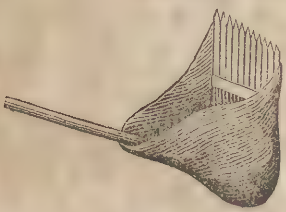
3, 4, The handles, 3 feet long, and 20 inches apart.

5, The fingers, or teeth, thirteen inches long.



The wheels are sixteen inches in diameter

This machine is drawn by one horse, and guided by a man or boy; it simply consists of an open box, about 4 feet square at the bottom, and about three in height, on three sides; to the fore part, which is open, fingers are fixed, similar to those of a cradle, about 3 feet in length, and so near as to break off the heads from the clover-stocks between them, which are thrown back into the box as the horse advances. The box is fixed on an axle-tree, supported by two small wheels, two feet in diameter; two handles are fixed to the hinder part, by means of which the driver, while he manages the horse, raises or lowers the fingers of the machine, so as to take off all the heads of the grass; and, as often as the box is filled with them, they are thrown out, and the horse goes on as before.



This instrument is called a *cradle*, and is made of an oak board about 18 inches in length and 10 in breadth. The fore-part of it, to the length of 9 inches, is sawed into fingers; a handle is inserted behind, inclining towards them, and a cloth put round the back part of the board, which is cut somewhat circular, and raised on the handle; this collects the heads or tops of the grass, and prevents them from scattering, as they are struck off by the cradle, which may be made of different sizes; being smaller in proportion for women and children, who, by means of it, may likewise collect large quantities. Mr. L'Hommedieu says, as soon as the clover is mown, it should be immediately raked into small heaps, and exposed [about three weeks] in the field, to promote the decay of the husk, as otherwise it will be difficult to obtain the seed. These heaps should be occasionally turned, especially during wet weather. It may, however, be easily ascertained, whether the husks are sufficiently rotten, or dry, by rubbing the heads or tops between the hands: when that is effected, they should be housed, and the seed threshed out when convenient, and cleared with a wire riddle. Lastly, this species is a valuable substitute for the common clover, as it continues much longer in the land.

Upon the subject of collecting clover seed, Mr. L'Hommedieu observes further; by sowing three or four pounds of seed to the acre, on light loamy soils, which yield eight or ten bushels of wheat or rye per acre, the clover will not be profitable to mow, but standing thin on the ground, the heads will be well filled with seed. The fields are to be kept up next year, till the seed is collected, by the machine represented above. On rich lands, no seed comes with the first crop, but the second crop being shorter and thinner, is commonly well seeded. Sometimes, indeed, considerable quantities of seed are gathered from the first crop, on land where wheat has been cut the same year, the stubble, preventing the clover from growing too thick to produce seed. If the land be rich, and it is intended to sow the first crop, and collect seed from the second, eight lbs. are not too much for one acre.

Red clover is an essential article in the rotation of crops in Pennsylvania, and the immense riches which the whole state has acquired during the last twenty years, may, in part, justly be ascribed to this grass aided by the almost magical fertilizing power of gypsum, by which more

wealth has been introduced than would have resulted from the discovery of a gold mine.

3. The *procumbens* or hop-clover, or hop trefoil, which grows in dry meadows and pastures. It flowers in the months of June and July. When mixed with common clover, on light land, it makes a most excellent fodder. This plant is variously called back-grass and nonsuch.

4. The *repens*, or white-clover, which abounds in meadows and pastures. It also delights in light land, where it will thrive luxuriantly, if frequently rolled. It is usually sown with red clover, rye-grass, or barley, and is in blossom from May to September. It produces the sweetest hay on dry land, especially when mixed with hop-clover and rye-grass; and possesses this advantage over the common clover, that it will admit of being irrigated. Horses, cows, and goats eat it, but sheep are not fond of it, and hogs totally refuse it.

COAK, see COAL.

COAL. Mineralogists are by no means agreed in their arrangement of this important genus of mineral inflammables, we shall therefore with the less scruple differ in some degree from them all. It appears to be upon the whole the most convenient as well as more conformable to nature to include both the carbonaceous and carbono-bituminous fossils under a single genus, sub-dividing it into the families of Brown Coal, Black Coal, and Mineral Carbon.

1. *Brown Coal.* Imperfectly bituminous; of a brown colour, and vegetable texture.

Sp. I. Bituminized wood.

Its colour is brown approaching to brownish-black. Its external shape exactly resembles that of compressed trunks and branches of trees; its internal texture is precisely that of wood, retaining not unfrequently even the bark. It burns with a clear flame though with but little heat, and gives out a bituminous odour often mixed with that of sulphur.

Bituminized wood occurs usually in alluvial land among the beds of common brown coal; sometimes also forming beds by itself.

It is found in Britain at Bovey, near Exeter, in the isles of Skye and Cannay, in the coal strata of Mid-Lothian; in Bohemia and various parts of Germany; in France, Iceland, and Russia.

It passes into common brown coal and pitch coal, and is occasionally penetrated by quartz. It is employed as a fuel, but is greatly inferior to black coal.

Sp. II. Earthy Brown coal.

Its colour is blackish or wooden-brown or yellowish-grey: it occurs in mass, of a consistence between solid and friable. It is without lustre except when rubbed or cut, and then it becomes somewhat shining. It soils the fingers a little: its fracture is intermediate between uneven and fine earthy. It is very soft and falls easily to pieces.

It readily takes fire and burns with a weak flame and disagreeable bituminous odour.

It is found in similar situations with the preceding species: in the neighbourhood of Leipsig it occurs in beds from twenty to forty feet thick, and of great extent.

It is used as an inferior kind of fuel, especially in manufactories where a low degree of heat is required; for this purpose it is moistened with water, well beaten and made into brick-shaped masses. In the vicinity of Cologne a variety is found of a reddish-brown colour, which is prepared as a pigment under the name of Cologne umber.

Sp. III. Common Brown-coal.

Its colour is light brownish black passing into blackish brown. It acquires a polish by friction; is moderately hard.

And burns readily with a weak flame like half-charred wood and a disagreeable bituminous odour, when heated in close vessels it yields much charcoal and when ignited in an open fire it leaves behind a small quantity of white ashes.

Brown coal is found in the territory of Hesse, and various parts of Germany, in Denmark, Greenland, Italy, and in England.

It is used like the preceding species, for fuel. It passes into bituminous wood and moor-coal, sometimes into pitch-coal.

Sp. IV. Moor coal.

Its colour is dark blackish brown. It occurs in mass forming very thick beds, and is characterized by being always full of rifts and crevices. Internally it displays a considerably resinous lustre. It is tender, remarkably frangible, and light, and in its chemical characters it resembles the preceding species.

It occurs in alluvial land and in the newest floetz-trap-formation. It is met with very frequently in Bohemia, and is also found in Transylvania and other parts of the Austrian dominions, in Denmark and the Faroe islands.

2. *Black Coal.* Perfectly bituminous; of a black colour.

Sp. V. Slate coal.

Its colour is perfectly black passing into greyish-black, and often presents more

or less of an irridescent tarnish. It runs into the two following varieties.

Var. 1. Foliated coal.

This differs from the preceding in having a somewhat higher lustre, and a strait foliated longitudinal, and slaty cross fracture. It is also softer and more subject to decomposition.

Var. 2. Coarse coal.

The cross fracture of this displays a coarser granular texture than common slate-coal; its colour is not so pure a black, it possesses less lustre, and is considerably harder.

Most of the common coals belong to this species, and from the different phenomena which they exhibit during combustion, a great number of varieties are known in the market, and are sufficiently obvious to an experienced eye, which yet cannot be described.

The two points which are principally to be attended to with regard to common coals, in an economical point of view, are the intensity of the heat and the duration of the combustion, and these are chiefly influenced by the proportion of asphalt which they contain. Coals in which the bituminous part is chiefly maltha, with only a small quantity of asphalt, kindle very easily, burn briskly and quickly with a bright blaze, cake but little, require no stirring, and by a single combustion are reduced to loose ashes such are the Lancashire coals, the Scotch and most of those which are raised on the western side of England. Those on the other hand in which asphalt prevails kindle difficultly, and after lying some time on the fire become soft and in a state of almost semifusion; they then cohere or cake, swell considerably, and throw out on every side tubercular scoriæ accompanied by bright jets of flame. In consequence of the cohesion and tumefaction of the coals, the passage of the air is interrupted, the fire burns hollow and would be extinguished if the top were not broken in from time to time. The produce of ashes is smaller than in the free burning coals, the greater part of them being mixed with the carbonaceous part of the coal and forming grey scoriæ, commonly known by the name of cinders, which being burnt again with fresh fuel give out an intense heat, and are slowly reduced, partly to heavy ashes and partly to slag. The best coal of Northumberland, Durham and Yorkshire is of this kind: it burns longer and gives more heat than the preceding, and in general bears a higher price.

Slate coal is found principally in the independent coal-formation, as it is the most widely diffused of any of the species. It is often mixed with pyrites, and penetrated by thin veins of quartz or calcareous spar.

Sp. VI. Pitch coal.

Its colour is velvet black passing sometimes into brownish black. It occurs in mass, in plates, and sometimes in the shape of branches with a regular woody structure. It has a brilliant resinous lustre.

It burns with a greenish flame and a strong bituminous smell, and leaves behind a little yellowish coloured ash. It occurs principally in the newest floetz-trap coal-formation. It is used as fuel, but the finer and harder pieces are worked into various trinkets, and go under the name of jet. It occurs in detached fragments in the Prussian amber mines, and is there called black amber.

Sp. VII. Cannel coal.

Its colour is dark greyish black. It occurs in mass: has a glistening resinous lustre. It is very inflammable, and crackles, and flies while burning, especially if it is not laid in the direction of the cross fracture: it flames much and burns quickly, but does not cake, and leaves behind from 3 to 4 per cent of ashes.

Cannel coal occurs in the independent coal-formation. It is found in great plenty and remarkably pure in Wigan in Lancashire, and occasionally in most of the other English collieries.

Its chief use is as a fuel, but the purest Wigan cannel will bear to be worked in the turning lathe, from which it receives a high polish: hence it is shaped into various ornamental utensils, and when cut into beads is not to be distinguished from jet. See Ampetites.

3. *Mineral Carbon.* Destitute of bitumen; consists of charcoal, with various proportions of earth and iron.

Sp. VII. Mineral charcoal.

Its colour a greyish black. It occurs in plates and irregular pieces. It has a glimmering silky lustre, and a fibrous fracture discovering its ligneous texture. It soils the fingers, is soft and friable. It is somewhat heavier than common charcoal, and is easily reduced to ashes before the blowpipe without flaming.

It occurs in thin layers in brown coal, slate coal, slaty glance coal, and pitch coal, but in too small quantities to be made any separate use of.

Sp. VIII. Glance coal.

Of this there are three varieties.

Var. 1. Conchoidal glance coal.

Its colour is iron-black, inclining to brown. It occurs in mass and vesicular, the interior of the vesicles has a steel blue tarnish.

It is of rare occurrence, having been met with only in the Meissner in Hesse, and at Newcastle.

Var. 2. Columnar glance coal.

Its colour is dark greyish black, sometimes verging to brownish black, the sides of its natural divisions are often covered with a yellow ferruginous earth. It is soft, very easily frangible, light, and of a shining lustre.

It burns without flame or smell, and leaves a greyish white ashes. It has hitherto been only found at the Meissner in Hesse, where it occurs together with other coal in the newest floetz-trap-formation.

Var. 3. Slaty glance coal.

Its colour is dark iron black, verging on steel grey, it has bright metallic lustre, and breaks easily into indeterminate angular fragments.

This mineral occurs in imbedded masses, beds and veins in primitive, transition, and floetz rocks. It is found in gneiss, in micaceous and argillaceous schistus, in mineral veins, with calcareous spar, native silver, mineral pitch, and red iron ore, and has been discovered by Jameson in the independent coal-formation in the Isle of Arran.

Sp. IX. Plumbago.

Its colour is dark iron black, passing into steel-grey. It occurs in mass, in kidney-shaped lumps, and disseminated. It has a glistening metallic lustre: its fracture is small somewhat curved foliated approaching to scaly, or granular uneven; in the great it is slaty. It occurs generally in granular or scaly distinct concretions: it takes a polish by cutting or rubbing, gives a dark lead-grey streak, is unctuous to the feel, soft, and not very brittle.

It is found in primitive and transition rocks in England, Scotland, France, Spain, Germany, &c.

Its most important use is a material for pencils to write or draw with, for which purpose none that has yet been discovered is comparable to that from Borrowdale in Cumberland: it is sometimes used to lubricate machinery with instead of oil; also to protect iron from rust, and, when mixed with clay, as a material for crucibles.

Modern mineralogists distinguish three different kinds of coal-formation, or three series of rocks entirely different from each other, which contain coal; and as a knowledge of these is important in an economical point of view, we shall give a short account of the principal facts that are ascertained on this subject.

The independent or true coal-formation consists essentially of extensive parallel strata of coal, covered by strata of shale, which contain impressions of vegetables, and sometimes the remains of fresh-water shell-fish. Beneath each stratum of coal is generally a stratum of somewhat greasy indurated clay, called by the miners *clunch*, which is usually, if not always, destitute of those organic remains that characterize the shale. It rarely happens that the slate belonging to an inferior stratum of coal is in immediate contact with the clunch of a superior stratum, the coal seams being generally separated from each other by beds of various coloured sand-stone, of clay, of bituminous shale, of ratchil or rubble-stone, of a soft decomposing clay, porphyry, or grunstein, called by the English miners rotten-stone, of argillaceous iron ore, of marl, and of secondary limestone. Sometimes one, often several of these strata interpose between the seams of coal in irregular alternation, and there are extensive colleries in which some of them, especially the limestone, are entirely wanting. The number of seams of coal in any particular formation or coal-field is extremely variable; it seldom however happens that there are more than three or four worth the expense of working. The uppermost seam is generally shattery, and very much mixed with earth and pyrites. The parallelism of the various strata is for the most part very exactly preserved, though where a very thick bed of sandstone occurs, the strata above and below it have not always the same parallel. The general position of the beds in the independent coal-formation is scarcely ever horizontal, and never vertical, though occasionally forming an angle of about 75°. The regularity of the dip, however, is frequently interrupted by partial disruptions, slips and sinkings of the strata, emphatically called by the miners *troubles*, which appear like great cracks and are filled with sand, gravel, clay, &c. and afford a free passage for the water. Sometimes the strata are divided by vertical walls of basalt, rising from an unknown depth to the surface, and of vast length; these are called by the miners *dykes*, and differ from the slips in being impermeable to water, and in simply dividing the strata without altering their direction: both the slips and the dykes however are observed to shatter and pulverize, and decompose the coal in their immediate vicinity. The particular species that are found in the independent formation are slate coal, with its varieties, cannel coal, and sometimes pitch-coal. Almost all the English coals, and those in the neighbourhood of Liege, are found in this formation.

The second coal-formation is characterized by the newest floetz-trap. In this

the strata are not so numerous nor so perfectly parallel as in the former. The coal is not covered with shale, but with clay or bansalt, in which are found neither vegetable impressions or animal remains. The beds which compose this formation are wakke, basalt, both amorphous and columnar, grunstein porphyry, and argillaceous iron ore. Slips or disruptions of the strata are of frequent occurrence. The species of coal which it contains are principally pitch-coal, also moor and glance coal, and sometimes slate-coal. The chief collieries of Scotland, those of Auvergne and the central parts of France, of the Meissner in Hesse, and the Mittelgebirge in Bohemia are examples of this formation.

The third coal formation occurs in alluvial land, and possesses many characters that distinguish it from the preceding ones. The only strata which are found in it, are clay, sand, and gravel. The seams of coal do not preserve the same thickness through the whole of their extent, nor is the parallelism of the earthy strata by any means regular, sudden elevations and depressions in the same stratum, frequently taking place. There are no slips or dykes in this formation, and every appearance concurs to prove its very recent origin. The species of coal that it contains belong chiefly to the brown-coal family, namely bituminized wood, earthy and common brown-coal, moor-coal, and rarely pitch-coal.

The signs of coal are very uncertain both in the floetz-trap and alluvial formations. In the first of these no appearance is to be depended on exceptthe actual outburst of coal, or of a bed of clay, containing fragments of coal. In the second, the only probable indication is clay, with branches and trunks of trees: petrified wood is often found in considerable quantity in *sandstone* strata, without there being the slightest probability of a bed of coal beneath.

The independent coal-formation has however more numerous signs, and those better to be depended on. Being the oldest of the three formations it is situated nearer the primitive and transition rocks than the others, and in general appears to rank immediately after secondary limestone: where beds of this adjoin, and rest upon slate, as is frequently the case in the northern and western parts of England, the independent coal-formation is generally observed within a little distance of the limestone on the opposite side of the slate rock, and therefore divided from it by the limestone. The extensive collieries of Flint, Ruaboe and Chirk in North Wales, of Glamorganshire in South Wales, of Coalbrook-dale in Shropshire, and Kingswood, near Bristol, are all examples of this, all of them commencing immediately in the vicinity of secondary limestone, which itself on the opposite side may be traced into slate: in some of these instances the limestone does not exceed a few hundred yards in width, while in others it amounts to several miles. Among the strata of which the coal-formation itself is composed, limestone, clay, and marl, are the least certain indications, as these are met with very frequently in formations unconnected with coal. White micaceous sandstone, especially when in thin layers is a promising sign: argillaceous iron is still more so; but shale with vegetable impressions, or the tenacious blue clay into which it decomposes, is the strongest indication of all: there are few situations in which this shale or clay occurs where an accurate search will not discover detached fragments of coal, and often the crop of outburst of the seam itself; and even should these be wanting, it will be well worth while to employ the borer and pierce through the shale, immediately beneath which a seam will be found, if it belongs to the coal-formation.

From the vegetable remains with which the shale that lies upon coal is always filled, from the ligneous texture which may be traced here and there, even in the most compact species of coal, and from the regular and gradual transition of bituminized wood through pitch coal, and slate coal, into glance coal, it is now generally supposed that all coal (plumbago excepted) is of vegetable origin. As to the precise mode and agent by which the process of bituminization has been brought about, the manner in which, and the period when the successive strata of the coal-formations have been deposited, there exists and probably ever will exist, various theories more or less ingenious and consistent, which although in all likelihood very remote from the truth are valuable as exciting to further enquiry, and as convenient methods of arranging and collecting many very curious and important facts. To enter into the detail of these, however, would be deviating too far from the practical objects of the present work.

The great use of coal is as a material for fuel, and it is used either in its crude state, or after it has been converted into coak by a process analogous to that by which wood is made into charcoal.

Unprepared coal is employed in all manufactures in which liquids are to be boil-

ed by evaporation, such as brewing, salt-making, distilling, and dyeing; it is used also by glassmakers, blacksmiths, brick, and limeburners, and in all metallurgical processes in the large way, where fusion is performed in a reverberating furnace. As a domestic fuel also it is used for the most part without any preparation; but in some places where coal cannot readily be procured, it is reduced by pounding, to the consistence of small gravel, and worked up with an equal weight of tenacious clay, and moulded into balls of the size of the fist. These being first well dried in the air are made use of as fuel, and are found to burn longer and give out more heat than the coal would do without this addition. The only inconvenience attending these balls is, that they do not readily inflame, and therefore it is necessary at the kindling the fire to employ common coal, and not to add the balls till a sufficient body of fire has been collected.

In blast furnaces, and the upright smelting furnaces for iron and copper, coal cannot be used in its crude state, both because its sulphureous vapours would injure the quality and diminish the quantity of metal, and because by its caking the current of air would be obstructed, and the whole process thrown into disorder: neither can this combustible be employed, except in the state of coak, for drying malt and other similar processes in which smoaky fuel would be extremely prejudicial. Coal is deprived of its bitumen and other volatile parts, or in other words is made into coak, in various ways. The simplest mode is to dispose it in beds, from 40 to 60 yards long about cix feet wide and three feet high, in the open air, and kindling it in various parts, to allow the combustion to proceed till the mass is of a glowing red and ceases to smoke: being now taken to pieces and spread abroad the fire soon goes out, and the residue is found to be a light spungy scoriform substance (technically called coak or cinders) not so easily inflammable as coal, but when once kindled giving out an intense heat without either caking or smoaking. The above is apparently a very wasteful process, not only because the volatile matters are allowed to escape, but by this free exposure to the air a considerable portion of the carbonaceous part is also lost: it has however this advantage, that the sulphur is at the same time entirely got rid of, which cannot be done by close distillation, and in consequence the fuel is much better fitted for those purposes in which the presence of sulphur would be detrimental: for this reason doubtless it is that all the coak consumed in the numerous iron forges of this country is thus prepared. Another method of charring coal is to burn it in large vaulted ovens till it ceases to flame: this is more economical than the former, both because the product of coak is greater, and because the slack or small coal of the caking kinds may be employed for this purpose; all the volatile parts however are lost, and the coak is not entirely desulphurated.

In the county of Saarbruck on the Rhine, are some establishments for making coak and lamp-black at the same time, which perhaps might be found worthy of imitation in this country. The furnace is a long cylinder of brick-work placed somewhat in a slanting direction, terminated at the lower end by a grate and register door, and opening at the other extremity into a large vaulted chamber: the first chamber communicates with a second similar to it, except that it is smaller, and this latter by means of an aperture in the cieling opens into a chimney, a sack of loosely-woven cloth being interposed. The process begins by lighting a fire in the furnace and supplying it gradually with coals, till the furnace is about half full, then by means of the register in the door, a small current of air is admitted till the coals cease to smoke; at this period the door is opened and the contents of the furnace are raked into a hole below its mouth, where they are extinguished, leaving however, in the furnace, a sufficient quantity of lighted coals to kindle the next charge. While the coals are thus charring the smoke passes into the large chamber, where it deposits the greatest part of its soot, and the rest is collected in the small chamber, and in the sack which covers the opening into the chimney. By a careful regulation of the draft it appears probable that the coal might be as completely desulphurated, and with as little loss as in the open air, and the lamp-black would be nearly a clear gain: 100 lbs. of coal thus treated afford about 33 lbs. of coak, and $3\frac{1}{2}$ of lamp-black.

Coal, when heated in close or nearly close vessels, affords a vast quantity of a highly inflammable gas (already described as a variety of Carburetted Hydrogen) of Coal-Tar, or Petroleum, and of impure carbonated ammonia. From a laudable desire of saving the two latter valuable products, which had hitherto been allowed to escape in the process of coaking, Lord Dundonald erected, some years ago at Coalbrook-dale, and we believe elsewhere, a series of buildings to serve as a kind of distillatory apparatus, in which he prepared coak, and at the same time collected the petroleum and ammonia dis-

engaged in the process: his success was complete, as far as the distillation was concerned, but the undertaking was shortly abandoned in consequence, as we understand, of the sulphur contained in coak thus made, which rendered it unfit to be used in the furnaces. Indeed it is manifest, that in order to decompose the pyrites with which all coal more or less abounds, it is necessary to expose it while burning to such a stream of air as shall destroy both the petroleum and ammonia, and leave no opportunity for the exertion of economical ingenuity, except in the collection of soot and increasing in some degree the product of coak.

Tar distilled from coal, was thought by Lord Dundonald, to be far superior to the common vegetable tar, in preserving timber from the effects of the weather, and the bottoms of ships from the destructive worm of the West Indies. Some comparative experiments were tried at New York about thirty years since, by which it appeared, that boards covered with common tar, and sunk in the river for several months, were much eaten by worms, while a plank covered with the coal tar remained untouched. In consequence of this apparent proof of superiority, the bottoms of several vessels were coated with the tar, bought at the rate of 40 dollars per barrel. But the result of these trials has not served to extend and insure its character.

Capt. Truxton applied it to the bottom of a ship, and discovered nothing in it like a safe-guard from the worm; and informs us that some years after capt. Sarley, of New-York, commander of the ship America, payed all the timbers and planks of his vessel with it, as a preservative of the wood, and on the ship's return from her first voyage, it had caused a manifest decay of the frame.

The United States abound with various kinds of excellent coal. In the western counties of Pennsylvania, on the banks of the Schuylkill, and in Virginia, there are immense beds; it has also been lately found on the river Rariton, New Jersey, and at Newport, R. I.

A few years ago, a body of coal was discovered in the county of Northampton, Pennsylvania, upon the river Lehigh, of a bright black shining appearance. It gives an intense heat, emits very little smoke, but requires a strong blast to inflame it. This mine will one day prove a source of infinite convenience to Philadelphia: for it requires but little foresight to be able to assert, that at the rate we go on in wasting wood, it will be in a few years out of the power of the majority of the people to use it for common fuel. The river Lehigh, at present, is not sufficiently clear of obstructions, to enable the proprietors of the mine to bring the coal down to Philadelphia; but a lottery was on foot to raise the necessary sum to render the river navigable, and it is to be hoped the proprietors will be enabled to accomplish the important object.—The analysis of this coal by the late Professor Woodhouse, may be seen in the Medical Museum.

COBALT is a semimetal, of a whitish grey or steel colour, hard and brittle; of a dull, close-grained fracture, and moderate specific gravity. It is rather more difficult of fusion than copper; does not easily become calcined; and its oxide is of so deep a blue colour as to appear black.

To obtain the metal pure, Tromsdorff recommends to mix eight parts of finely pulverized zaffre with two of dry nitrat of potash, and one of charcoal powder, and project them by small quantities into an ignited crucible: to repeat this process three times with the detonated residuum and fresh quantities of nitre and charcoal: to mix the mass with an equal weight of black flux, and keep this mixture at a red heat for an hour. The metal thus obtained is to be pulverised, mixed with three times its weight of nitrat of potash, and detonated as before. This being powdered and washed to separate the arseniat of potash, the filtered residue is to be digested in nitric acid, which will dissolve the cobalt, and leave the highly oxidized iron untouched. Then evaporate the solution to dryness, re-dissolve in nitric acid, refilter lest some oxide of iron should have been retained, decompose the nitrat of cobalt by potash, wash the precipitate, and reduce it by heat.

Brugnatelli supposed he had discovered an acid in zaffre, which he called the cobaltic, but it appears to have been only arseniat of cobalt.

It may be observed on the subject of separation of iron from cobalt (as this is of consequence for manufacturing the finest possible colour from it) that when an alkali is added gradually to a mixed solution of the two metals, much of the iron precipitates before the cobalt falls, and this distinction is very obvious by the colour. Thus if carbonated potash be slowly added to nitrat of cobalt and iron, the first precipitate is a dull ochery slime, chiefly iron, after which the cobalt shews itself by a *violet* coloured precipitate, and thus a judicious addition of alkali (stopping when the violet colour is perceived) will alone purify the solution to a considerable degree.

Cobalt is never employed in the reguline state for any purpose of manufactory, the sole use of this valuable metal being to give various shades of blue colour to glass, porcelain, and other earthy mixtures, and when thus employed it must be in the state of oxyd. But the intensity of colour given by the oxyd in very small proportion is so great that it is found more convenient, after a due calcination, to mix and dilute it with a quantity of vitrifiable earth, and in this state it is generally sold, that is, either simply mixed with earth, when it appears as a brown gritty powder called *Zaffre* or *Azure*, or else already melted with a portion of vitrifiable materials when it becomes a glass of a most intense blue colour, which, when properly ground and sifted, forms the *Smalt* of the shops.

Preparation of Zaffre, Smalt, and Azure All the zaffre and smalt of commerce is prepared in the large way in several parts of Germany, and particularly at Schneeburg in Misnia, which affords a very lucrative trade to Saxony.

The cobalt ore is put on the hearth of a furnace like a baker's oven, so constructed that the flame of wood is reverberated on all sides over the furnace, and soon heats red-hot. A very dense arsenical vapour then begins to be given out, which is conveyed through a very long horizontal wooden square trough or chimney, sometimes as much as a hundred fathoms in length, where the arsenic is chiefly condensed, though Kunckel remarks that notwithstanding this enormous length of chimney, some of the vapours still escape through the further opening. The cobalt ore is calcined for some hours till it scarcely emits any more vapours, after which it is ground to powder, calcined a second time, again ground and passed through a very fine sieve. This powder is then mixed with two parts of powdered flints or quartz, moistened, and put in barrels, where it grows excessively hard This forms the *zaffre* in the state in which it is exported. The real reason of adding the flints appears to be for some purposes of concealment, the exportation of the simple calcined oxyd being forbidden under heavy penalties.

Smalt, sometimes also called zaffre, and when finely powdered, *azure blue*, is a very deep blue glass, made of the calcined ore of cobalt and some vitrifiable ingredients, which is used as a colouring matter for a variety of purposes. The proportion of the vitrifiable basis to the cobalt depends on the estimated goodness of the latter and the result of small trials. On an average, equal parts of the calcined cobalt ore, of potash, and of ground flints are taken. These are first *fritted* and then made into glass, in pots similar to those of the glass-houses, requiring from eight to twelve hours of fusion. When the blue glass is perfect, it is taken out with iron ladles, and dropped into cold water to crack it in every direction, and make it more easily reducible to powder, which is afterwards performed in a mill made of very hard stone inclosed in a wooden case. At the bottom of the glass-pots a quantity of regulus of bismuth is always found, (the ores of bismuth and cobalt being naturally mixed) and above it is a mixed alloy of arsenic, iron, and copper.

The grinding the blue glass is a work of labour and some difficulty. Several degrees of fineness are prepared by means of grinding and washing. These are well known by the general term of *smalt*, or, when in very fine powder, *azure*.

As a colouring matter smalt is very valuable, both on account of the fine intense blue which it produces, and for its comparative cheapness, and because it is not altered by any heat. In this last respect it is superior to *lapis lazuli*, the colour of which is entirely and permanently destroyed in a red-heat, but smalt will not mix with oil colours, and therefore can only be very partially used. Smalt is used, when mixed with starch, to give a slight blue to linen, or rather to correct the tendency to yellow which linen acquires when worn.

Zaffre is prepared also in Bohemia, Wirtemberg, Silesia, Lorrain, and some other parts of the Continent, but the Saxon is preferred, and yields to the proprietors an annual revenue of 200,000 crowns.

COCCULUS INDICUS, or Indian Berry, is the poisonous product of an oriental plant. It approaches the kidney bean in shape and size, is rough on the outside, and of a gray-brownish or black colour. This berry is principally employed in ointments for destroying cutaneous insects, reduced to a powder, and formed into a paste with flour. It is sometimes injudiciously used to take fish; which, on swallowing it, become intoxicated, lose their energy, rise to the surface of the water, float with the current, and thus fall an easy prey to the unskilful, barbarous sportsman. But, besides the indiscriminate and wanton waste that thus accrues, fish so taken afford an unwholesome diet.

On account of this intoxicating property of the cocculus indicus, brewers have sometimes resorted to the nefarious prac-

tice of mixing it with their liquors, thereby to give them a greater stimulating effect: but the bad consequences which result from it, joined to the very great probability of detection, have exploded its use, except by the most abandoned and depraved of mankind.

COCHINEAL. The substance known in commerce by the name of cochineal, is in the form of hemispherical shrivelled grains, about an eighth of an inch long, of a deep reddish purple colour, and covered more or less with a white down; they are very light, and easily rubbed to powder between the fingers. The merchants distinguish at least two kinds, called *grana fina* and *grana sylvestra;* of these the latter is not more than half the size of the former, and covered with a much longer down; on which account it always bears a much lower price in the market.

Cochineal was first introduced into Europe from Mexico about the year 1523, and was for some time supposed to be the berry or seed of a vegetable. It was at length however ascertained, that these grains were the females of a particular species of insect, called by naturalists Coccus cacti, and of the same genus as the Kermes (*Coccus Ilicis Linn.*)

The cochineal insect is a native of Mexico, and was in common use among the inhabitants as a dyeing drug, when the Spaniards first came into the country; since that period its use has become more and more general, not only in Europe, but in various parts of Asia; and as almost the whole of this valuable commodity is still raised in Mexico, Peru, and the adjoining Spanish settlements, it becomes every year an object of more sedulous cultivation than before.

The wild cochineal (grana sylvestra) feeds upon most of the species of cacti that are natives of Mexico, requires no particular care or attendance, and may be gathered six times in the year, there being so many generations of this insect in a twelvemonth: the time of collecting the cochineal is just before the female produces its young, as the animal perishes immediately afterwards. The cultivated cochineal (grana fina) is supposed to have originated from the wild kind: but this opinion appears very doubtful. If it be granted that the superior size of the former, and its want of those long white hairs or down which cover the latter may be the effect of domestication, there still remain two other distinctive characters which appear to be original; these are, its feeding only upon one species of cactus, the cochenillifer, or nopal, and its producing only three broods or generations in the year. The management of the cochineal insect is simple, but requires incessant attention. At the third annual gathering of cochineal, a certain number of females are left adhering to branches of the nopal, which are then broken off and kept carefully under cover during the rainy season; when this is over, the stock of cochineal thus preserved by each cultivator, is distributed over the whole plantation of nopals, where they soon multiply with great rapidity. In the space of two months the first crop is gathered by detaching the insects with a blunt knife, after which they are put into bags and dipped in hot water to kill them, and finally dried in the sun, by which they lose about two-thirds of their weight. The proportion of colouring matter contained in equal portions of the cultivated cochineal, the wild cochineal of Mexico and an inferior kind from St. Domingo, is as eighteen, eleven, and eight. The average quantity of fine cochineal annually consumed in Europe amounts, according to Dr. Bancroft, to 600,000 lbs. When thoroughly dry it experiences no change from long keeping in close packages: Hellot affirms that he used some which was 130 years old, and found it as good as if it had been quite fresh.

The colouring matter of cochineal may be extracted either by water or alcohol. The alcoholic solution is of a deep crimson colour, and on evaporation leaves a transparent residuum of a deep red, which has the appearance of a resin. The aqueous solution or decoction of cochineal is of a violet crimson colour; and this, if evaporated slowly to the consistence of an extract, and then digested in alcohol, communicates to the menstruum a colour similar to the preceding spirituous solution, a residuum of the colour of wine lees being left behind

The aqueous decoction of cochineal, if mixed with a little sulphuric acid, assumes a red colour, inclining to yellowish, and a small quantity of a fine red precipitate is thrown down. Muriatic acid produces nearly the same change of colour, but occasions no precipitate. A solution of tartar changes the cochineal decoction to a yellowish red, and a small quantity of a pale-red precipitate is slowly deposited: the supernatant liquor is yellow, but on the addition of a little alkali it becomes purple, the precipitate being at the same time redissolved. Alum brightens the colour of the infusion and gives it a redder hue; a crimson precipitate is deposited, and the supernatant liquor retains a similar tinge. A mixture

of alum and tartar produces a brighter and more lively colour, inclining to yellow: a precipitate is thrown down, but much paler and less in quantity than where alum alone is used. Sulphat of copper changes the colour of the decoction to violet, and a small sediment of the same colour very slowly subsides.

Cochineal is used either as the basis of that fine pigment called carmine and lake-red, or as a dyeing drug to tinge wool and silk, either scarlet or crimson, or the finer kinds of violet.

The preparation of carmine and lake-red is so valuable a process, and one so easily kept secret, and its perfection depends so much on nicety of manipulation, that none of the published methods, in all probability, will afford it of the very best quality. The following is perhaps the best of those which have yet been made public, and, if carefully pursued, will yield a pigment greatly superior to the carmine that is generally met with.

Into a 14 gallon boiler of well tinned copper, put ten gallons of distilled or very clear river or rain water (spring water will not answer the purpose). When the water boils, sprinkle in, by degrees, a pound of fine cochineal previously ground in a clean stone mortar to a moderately fine powder: keep up a moderate ebullition for about half an hour, and then add three ounces and an half of crystallized carbonat of soda: in a minute or two afterwards draw the fire, and then add to the liquor an ounce and a half of Roman alum very finely pulverized; stir the mass with a clean stick till the alum is dissolved, then leave it to settle for 25 minutes: draw off the clear liquor with a glass siphon, and separate the sediment from the residue by straining it through a close linen cloth. Replace the clear liquor in the boiler, and stir in it the whites of two eggs previously well beaten with a quart of warm water; then light the fire again, heat the liquor till it begins to boil, at which time the albumen of the eggs will coagulate and combine with the earth of the alum and the finest part of the colouring matter: this sediment is the carmine, and being separated by filtration, and well washed on the filter with distilled water, is to be spread very thin on an earthen plate and slowly dried in a stove: after which it is ready for use. The finest part of the colouring matter of the cochineal being thus separated, the residue may be employed in the preparation of red-lake in the following manner. Add two pounds of pearlash to the red liquor from which the carmine was precipitated, and return it into the boiler together with the dregs of the cochineal, and boil the whole gently for about half an hour; then draw the fire, and after the sediment has subsided, drain off all the clear liquor into clean wooden or earthenware vessels (the latter however are the best, as the alkaline solution is apt to dissolve a little extractive matter from the wood). Then pour upon the sediment a second alkaline ley, prepared by dissolving a pound of pearlash in two gallons of water, and boil this also upon the dregs for half an hour, by which process the whole of the colouring matter will be exhausted. Separate by filtration the liquor from the dregs, and return both the alkaline solutions into the copper. When this bath is as hot as the hand can bear, add, by degrees, three pounds of finely pulverized Roman alum, observing not to add a second portion till the effervescence from the first has entirely subsided. When the whole of the alum has been put in, raise the fire till the liquor simmers, and continue it at this temperature for about five minutes; at which time, if a little is taken out and put into a wine glass, it will be found to consist of a coloured sediment, diffused through a clear liquor. After standing quiet a while, the greater part of the clear supernatant liquor may be poured off, and the residue being placed on the filter, will there deposit the coloured lake; which, after being accurately washed with clean rain water, may be covered with a cloth and allowed to remain for a few days till it is half dry: it is now to be separated from the filter, to be made up in small lumps and placed in a stove to dry. By this management, a pound of good Mexican cochineal will afford one ounce and a half of carmine, and about a pound and a quarter of red lake.

If the colour is required to incline somewhat towards scarlet, this may be effected by grinding along with the cochineal from a quarter to half an ounce of the best annotta.

For the use of cochineal in Dyeing, see that article.

As cochineal is a native of Carolina and Georgia, its cultivation, as also that of the *cactus cocchinelifer* plant, ought to be encouraged, by the Southern planters, as a source of revenue in case their other crops should fail. For an account of the cultivation of this plant, and the preparation of the insect, the reader is referred to an essay on these subjects, by Edward Cutbush, M. D. in the *Archives of Useful Knowledge*, vol. i. p. 257.

COLOURING MATTER. For the nature of colouring matter see the article

Dyeing. Some of the most important of these, such as *cochineal*, *indigo*, *madder*, &c. have been analyzed by chemists, and are separately noticed.

COLOUR-MAKING. Colours may be considered either as certain matters used in dyeing, for the purpose of communicating colour, or as pigments employed in painting. We shall refer to the article Dyeing, for the colours used in that art, and confine ourselves in this place, to the colours used as pigments.

Colours are either opaque or transparent; oil, or water colours; simple, or compound; true or false. We shall not define these different pigments; but merely observe, that opaque colours are those which efface every other painting or stain; transparent colours possess the property of leaving the ground, on which they are laid, visible through them; water colours are pigments miscible, and used with water, either with or without size; oil colours pigments, mixed and used with oil; simple or compound colours, which are either simple in themselves, such as white and red lead, or compound, as the union of two or more colouring substances, such as blue and yellow, when blended together, make a green; red and yellow, an orange; and, lastly, true or false, which either retain their pristine tinge, as the former, or lose their colour entirely, or change into some other shade, as the latter.

§ 1. Black. There are a variety of pigments, which come under this head, such as lamp black, ivory black, blue black, German or Frankfort black, Indian ink, &c.

Lamp black. There are several processes used for preparing this colour. The following method, originally used in Sweden, is generally preferred. The impure juice collected from incisions made in pine and fir trees, is boiled down with a small quantity of water, and strained, while hot, through a bag; the dregs and pieces of bark remaining in the strainer, are burnt in a low oven, whence the smoke is conveyed through a long passage into a square chamber, at the top of which is an opening, with a large sack affixed, made of thin woolen stuff: the soot or lamp black, concretes partly in the chamber, whence it is swept out once in two or three days, and partly in the sack, which is occasionally agitated, in order to take down the soot, and to clear the interstices between the threads, so as to admit a free current of air. There are two species of lamp black in common use: one is the light soot, from burning wood, of the fine and other resinous kinds; and the other is prepared by a process called carbonization, which is effected in close vessels.

Lamp black is made in this city from tar. The Carolina tar is preferred. A barrel of tar by combustion, will afford 40 lbs. of soot, or lamp black. In this way, the black is prepared for printer's ink.

A patent was granted in 1798, to a Mr. Row, for a newly invented mineral lamp black. This is obtained from pit coal, or any other kind of fossil coal, by burning it, and collecting the smoke. An account of the process may be seen in the 10th volume of the *Repertory of Arts.* For the manufacture of lamp black from coal, see Coal.

For some purposes, it is of considerable importance to have the lamp black of the first quality. To purify it, it is advisable to put it into a subliming vessel, or to place it on an iron plate, made red hot; when the smoking ceases, the process is finished. Very fine lamp black may be obtained by collecting the smoke produced by the combustion of oil.

Spanish Black. This pigment is prepared by burning cork.

Ivory Black. This pigment is made by burning ivory or bone, in large cast iron cylinders; when the bone is brought to a red heat, the external air is *stopped off*, as it is termed, and the vessel suffered to cool. The bone, thus charred, is perfectly black, provided the process be properly conducted; it is then removed to the mill, and ground for use. As economy is necessary, in order to render the process less costly, it is the custom in some manufactories to collect the vapour disengaged (which is done by using bent pipes leading into barrels, partly filled with water) which consists for the most part of ammonia or volatile alkali blended with animal oil. The liquor thus obtained, when distilled, is tolerably pure, and is sold as spirit of hartshorn. Ivory black is frequently adulterated with charcoal, which is very injurious.

An opaque deep black, for the purpose of water colours, may be prepared, by grinding ivory black with gum water, or with the albuminous part of the egg.

The following extract from the specification of a patent granted to William Docksey, for considerable improvements in the manufacture of ivory black, may prove useful to the artist.

"First. To manufacture ivory black, I take the bones and sloughs of the horns of animals, and calcine them to blackness, in close or air-tight vessels. I then crush them in their dry state, between metal rollers, of about two feet diameter, until they are broken sufficiently small to pass

through a hopper into the eye of a mill-stone, and be reduced to powder between mill-stones, in a horizontal situation, exactly similar to the method of reducing or grinding corn or grain to flour. By a like process, the powder thus obtained is then partly passed through a dressing machine, constructed with brushes and fine iron or brass wire, upon a circular frame, inclosed within a rim, which receives it. Such part as passes through the meshes of the wire (which should be about sixty-eight to an inch) is sufficiently fine for use, and is damped down by a small quantity of water sprinkled upon it, and packed for sale; the coarser part is returned to the hopper, and ground over again between the stones."

Some advise the use of linseed oil, when the shavings or raspings of bone or ivory, are made use of in the small way; it is said, that after the charring, the black is more perfect than that prepared in the common process.

Trotters bones, calcined in the same way, afford a pigment called also ivory black, but more properly bone black. Any osseous substance, treated as before mentioned, will produce a black pigment.

German Black, or Frankfort black. This pigment is made by charring the lees of wine in a close iron vessel; and afterwards reducing the matter to powder. It has been made in this country by burning certain vegetable substances. The stalks and husks of grapes, charred in the same manner, produce a good Frankfort black.

Blue Black. This is similar to the former: it is made from burning vine stalks in a close vessel. Colour makers substitute a mixture of ivory black, and the common blue used for dyeing cloth.

Indian Ink. This colour may be made in the following manner:

Take dryed black horse beans, and burn them to a powder; mix them up with gum-arabic water, and bring them to a mass; press it in a mould made for that purpose, and let it dry. *Or,*

Take one ounce of lamp-black, two ounces of indigo, half an ounce of fish black; grind them with half water and half milk, and a little gum-arabic, and form tables thereof. The lamp-black must be cleared from all greasiness, by burning it in a clean pan, on a coal fire.

The Indian Ink, brought from China, is supposed to be the gall of a species of cuttle fish. According to Thomson, (V. 106,) a solution consisting of 20 grains of borax, 100 grains of lac, and four ounces of water, mixed with lamp black, constitutes Indian ink.

To make a fine Ink-powder to write or draw with. Take half an ounce of lamp-black; plumb or cherry-stones, vitriol, and gall-nuts of each half an ounce; burn them together in a crucible; add half an ounce of gum-arabic: beat all in a mortar to a fine powder, and sift it through a fine sieve; then put it up in a box, and, when you want to use it, dilute it with fair water.

§ 2. WHITE. There are a variety of whites used as pigments, such as flake white, white lead, pearl white, &c.

Flake white. Some writers confound this pigment with white lead, supposing that they are both produced from the same metal. According to Thomson (I. 366,) the flake white, and the pearl white, are the same as the magistery of bismuth, made by dissolving bismuth in nitric acid or spirit of nitre, and precipitating the metal by the addition of water. The metal thus precipitated, is in the form of white oxyd, containing about 10 per cent. of oxygen.

White lead. This is prepared by corroding lead by the vapour of vinegar. See Lead.

Spanish White is nothing but chalk, ground generally in tubs, the bottom of which is paved with small stones of a hard quality, or has one large hard bed-stone instead thereof, and a stone on edge is fixed to an upright axle, both which go round by the means of a water-wheel, steam-engine, or horses.

The chalk is broke into small lumps about four ounces each, and thrown into the tub in which it is ground; but the tub is previously charged with a large quantity of water, and as the grinding operation commences, the chalk unites with the water, its finer particles rise to the surface, and, as a small stream of water is constantly running into the tub, and fresh quantities of chalk are added, the level of the mixture rises to a certain height, finds its way through an aperture of the tub near the top, and is discharged into a large reservoir, by which the two operations of grinding and washing are performed at the same time with a small expense. After the ground chalk has stood a sufficient time to subside, the water is run off, and the chalk being so stiff as to cut with a spade, is then removed to a place to dry, either by the air or by stove heat: the former of these is termed *stiffening*, the latter is called *drying*, and is the finishing process.

Chalk, taken into the north coasts of England, at the chalk wharfs on the Thames, costs about 2*s*. 6*d*. per ton, and when made into Whiting in the North, sells from 16*s*. to 20*s*. per ton.

French Whiting, or Paris White, has

not been made in England above 50 or 60 years; the manufacture of it was brought by a Dutchman, who settled in a sea-port town in Yorkshire, and who, by it, and his mode of refining and depurating rapeseed oil, and linseed oil, acquired a large fortune, and became a respectable banker.

Egg-shell white, and *Oyster-shell white*. These are only egg-shells and oyster-shells calcined, by which the animal gluten is destroyed.

Nottingham white. This pigment is nothing more than white lead, prepared by corroding lead by means of sour ale instead of vinegar.

Glass white. Take crown glass, and beat it to an impalpable powder; take also finely pulverized sulphur; mix them together in a large crucible with a cover to it; lute it close, and put it upon a charcoal fire, so as to make the crucible red hot all over; when it is thus heated, take it off the fire, and let it cool; then take off the cover, and grind the matter upon a stone with clear water, and temper it either with oil or gum-water: it will give a good white colour.

Darcet's composition for white.

The following composition has been used with success for painting:

Take cheese or curd well drained, 5 oz.
Slacked lime ¼ oz.
Whiting, 10 oz.
Fine powdered charcoal, 1 dram.
Water, 3 oz.

At the moment of commencing the operation, a certain quantity of strong quick lime must be slaked in the least possible quantity of water. This is the surest and most speedy method of reducing it into fine powder. The lime is to be sifted, in order to separate the pieces which do not fall down, and of the powder seven grammes are to be weighed. The quantity of cheese above indicated is to be taken and pounded till it has the appearance of salve, and with this the seven grammes of lime are to be mixed, and the mixture well agitated, which loses its consistence, and acquires that of hot new made glue.

On the other hand, whiting in powder is taken, and added to the water and the charcoal, and the whole accurately mixed. This mixture may be passed through an open sieve, in order that it may be reduced to a liquid homogeneous paste.

The mixture of lime and cheese is then to be added, and carefully mixed with that of the whiting and charcoal diffused in water. The colour is then finished.

Calcined Hartshorn. This preparation is formed by calcining or otherwise burning, the shavings of hartshorn, until all the gelatinous matter is destroyed. It is considered the most useful of the earthy whites.

§ 3. Red. Colours, which come under this head, are numerous; of these, carmine, rose pink, and vermilion, are the principal.

Carmine. This colour is produced from cochineal. There are various modes of preparing it. Any process will answer for extracting the colour, so that the colouring matter of the insect shall be disengaged from the extraneous matter. This is usually accomplished by making an infusion in water, and adding thereto a solution of alum, or nitro muriate of tin. See Cochineal.

Red Lake. This colour is also prepared from cochineal, though other substances have been used. For the preparation of this pigment from cochineal, see that article.

Florentine lake. The best sort may be prepared from the sediment of cochineal, that remains in the kettle, after making carmine, adding to it a small quantity of cochineal, or Brazil wood, and precipitating the colouring matter with a solution of tin.

Madder lake. This is formed nearly in the same manner as the foregoing.

According to Merimé, if madder be steeped a certain time in water, and a small quantity of potash added to the solution, a fine red lake will be obtained.

An improvement in the method of extracting the red of madder for lakes has been published by Sir H. Englefield, for which the gold medal of the Society for the Encouragement of Arts was given to the inventor. It is founded on the discovery that the red colouring part is scarcely soluble in cold water, but in the common method of extraction is chiefly suspended by means of the mucilage of the root. The principal process is the following: Inclose two ounces (troy weight) of the finest Dutch madder, known in commerce by the name of *crop madder*, in a bag, capable of containing three or four times that quantity, made of strong and fine calico. Put it into a large marble mortar, and pour on it a pint of soft river water, pressing the bag in every direction, and rubbing it as much as may be without danger of bursting. The water will soon become quite opake, and loaded with colouring matter. Pour off the water, and add another fresh pint of water, triturating it with the madder as before; and repeat the operation till the water, the last added, comes off but slightly tinged. About five pints will be required to exhaust the colour; after which the root, if taken out and dried, will be found to have lost

11-16ths of its weight, and with it its peculiar smell, and the colour will be a light nankeen or cinnamon.

The water loaded with the colouring matter must then be put into an earthen or well tinned copper vessel, (not iron) and heated till it just boils. Then pour it into a large bason, and add an ounce of alum dissolved in a pint of hot soft water, stirring the mixture carefully. Then add about 1½ ounce of a saturated solution of carbonat of potash, which will excite an immediate effervescence, and a subsequent precipitation of a coloured lake. After standing till cold the lake is to be collected, well washed with repeated quantities of warm water and gently dried. It will be then found to weigh about half an ounce, or a fourth part of the madder employed.

The above madder lake, which is very beautiful, is found by analysis to consist of more than 40 per cent. of alumine. The rest is the colouring matter of the madder. See MADDER.

Rose Lake, or *Rose Pink.* This is a delicate colour, inclining more to purple than scarlet. It is prepared from chalk coloured with a decoction of Brazil wood, brightened by an alkali, which renders it liable to fade. This pigment, therefore, is nothing more than the colouring matter of Brazil wood, combined with chalk. The colour may be improved by the addition of a solution of tin to the decoction of the wood, previously to the addition of chalk. A beautiful lake may be obtained from the same wood, in imitation of carmine, in the following manner:

Boil three pounds of the raspings of Brazil wood with three pounds of common salt in three gallons of water; filtre the hot liquor through flannel, and add to this a warm solution of five pounds of alum in four gallons of water. Now, dissolve, or have ready dissolved, three pounds of the best pearl-ash in a gallon and a half of water, and filtre it also; and put the liquor to the other, gradually, till the whole colour is precipitated. If it be purple instead of red, add a fresh quantity of alum till a scarlet hue is produced; and then proceed with the sediment as in the former article. By the addition of half a pound of seed-lac to the solution of pearl-ash before it is filtered, a lake will be produced, that will stand well both in water and oil, but is not so transparent in oil as without the seed-lac.

The lake from Brazil-wood may be also made, by adding half an ounce of Spanish anotto to each pound of the wood; but the anotto must be dissolved in the solution of pearl-ash.

The effects of the solutions of tin and alum on Brazil wood are the most important to the colour-maker. Alum added to the watery decoction of the wood gives a copious fine red precipitate, inclining to crimson and subsiding slowly. The supernatant liquor also retains the original red colour of the decoction, but if enough of alkali is added to decompose the alum, its earth falls down and carries with it nearly all the remaining colouring matter of the wood. In this way a fine crimson lake, imitating the cochineal carmine, may be prepared; which therefore consists of alumine, intimately combined with the colouring matter of the wood a little heightened.

Nitro-muriat of tin added to the decoction, separates the whole of the colouring matter, which falls down in great abundance in union with the oxyd of tin, and the liquor remains colourless.

Vermillion. This is a bright scarlet pigment, called the red sulphuret of mercury, composed, as its name imports, of sulphur and mercury. When in its crude state, it is called *cinnabar.* See MERCURY.

Red Lead. This is an oxyd of lead, prepared by melting lead, and exposing it to the air in a reverberatory furnace See LEAD.

Indian Red. This is a very useful colour, answering some of the purposes of lake; it stands well both in water and oil.

Venetian Red, is a native red ochre, rather inclining to the scarlet than crimson hue: it is not of so good a colour as the common Indian red, and is chiefly used by house painters. It is often imitated by colcothar.

Spanish brown, is also an earthy substance, the base of which, like many other of the earthy pigments, is alumine, coloured with oxyd of iron.

Red Ochre, as it is usually found in the shops, is yellow ochre, heated red hot in the fire, till the colour changes from yellow to a red. In this manner, red ochre is manufactured in the United States. Ochres, both the red and yellow, have been found native, of an excellent quality, in this country.

Red Chalk, or *Reddle.* This is an ore of iron in the state of red oxyd, usually combined with more or less alumine. It is used for marking in the manner of a crayon. It stands perfectly well, and may be used both in water and oil. It is made artificially in this city.

Burnt Terra di Sienna. This colour is made by calcining the raw *terra di sienna*, till it acquires a red colour. It is of a very rich tint, and is much used both in water and oil. It stands well in both.

§ 4. Orange. The genuine orange paints, are principally red orpiment, and orange lake. The first is a sulphuret of arsenic; formed, of course, of arsenic and sulphur. The other may be prepared from turmeric, by infusing it in spirit of wine, and adding a solution of tin.

Orange may be formed by mixing red and yellow colours together, in due proportions. The following formulæ will also form a good orange colour:

Boil four ounces of the best Spanish anotto, and one pound of pearl-ash, for the space of half an hour, in one gallon of water. Strain the tincture, and mix it gradually with a solution of a pound and a half of alum to six quarts of water, desisting when no ebullition ensues. Treat the sediment as is usual in preparing lake, and dry it in square bits, or round lozenges.

§ 5. Yellow. The principal colours of this kind are, King's Yellow, Naples Yellow, Dutch-pink and Turbith Mineral.

King's Yellow. This colour is orpiment purified, and consists of arsenic and sulphur. It is of a bright yellow, but very apt to fade, on which account, as well as from its great price, it is but seldom employed.

Naples Yellow. The true Naples yellow is found near Naples, and consists of a kind of lava, unchangeable by fire and by acids. To prepare it artificially, the following process may be used: Take twelve ounces of white lead, one ounce of alum, one ounce of sal-ammoniac, and three ounces of diaphoretic antimony; put them into an unglazed pipkin, and expose them in a moderate heat for the space of eight hours. Thus will a beautiful yellow be obtained, such as the artists of Italy, term Giallolino.

If a bright golden colour be wanted, add half an ounce more of antimony, and a quarter of an ounce of sal ammoniac.

Turner's Patent Yellow. If two parts of common salt be dissolved in water, and one part of litharge added, and boiled for some time, the soda of the common salt will be disengaged and held in solution, whilst the lead will unite with the muriatic acid into a white powder. If this be melted in a crucible, patent yellow will be formed. Or, according to Dr. Pennington, if two ounces of spirit of salt (muriatic acid) be added to one pound of litharge in a mortar holding about a pint, and lined with a mixture of four parts of sand, and one of clay mixed up with water, and the mortar heated *white* in a furnace, the matter will fuse, and form when cold a beautiful patent yellow.

Masticot or Massicot. Take any quantity of white lead; put it into a crucible, and expose it to a degree of heat that will turn it yellow; which may be exactly ascertained by inspection only. See Lead.

Turbith Mineral. If mercury be boiled in sulphuric acid, a compound of a white colour, composed of the acid and oxyd of mercury, will result; which, when washed with boiling water, will afford a yellow pigment, or sub-sulphate of mercury, known under the name of Turbith mineral: this pigment is but little used.

Chromic Yellow. This pigment is rare and high. It is made by decomposing chromate of potash by nitrate or acetate of lead. The chromic acid passes to the lead, forming the chromic yellow, or chromate of lead, whilst the nitric or acetic acid passes to the potash: the former is to be collected on a filtre, washed, and dried. The chromate of potash is prepared from the ore of chrome. See Chrome. This pigment has been prepared in this country by several gentlemen. The ore is found near Baltimore.

Weld Yellow. This colour is prepared of the weld or dyer's weed. It is used by paper-hanging manufacturers. Messrs. Collard and Frazer, have given the following process for preparing it: Put four pounds of whiting into a copper boiler, and add to it, four pounds of water. Apply heat, so that the whiting may be reduced to an uniform paste or cream. Add gradually 12 ounces of alum, previously pulverised; carbonic acid will be disengaged in effervescence. When it ceases, the bases will be formed. Place the weld, with its roots uppermost, in another copper boiler, and cover it; add a sufficient quantity of water; make the liquor boil for ten or fifteen minutes, and strain it off through a flannel filtre. Add now the last mentioned liquor to the bases; apply heat; and the colour will be formed. Collect it, and dry it for use.

Indian Yellow. This is the brightest of all the yellows, for water colours, and is perfectly durable. It is said to be procured from the urine of the buffalo. In the East Indies, it is a very common and cheap colour; the natives there use it for colouring their calicoes, which they do without any mordant; so that the colour is washed out again when the cloth is dirty.

Yellow Ochre. This is an earth, coloured by oxyd of iron. It is a cheap colour, and not very bright, but is valuable, on account of its standing well. Ochre has been found in abundance in the United States.

A Yellow from Copperas may be made by adding to two pounds of copperas dissolved in water, one pound of lime.

Roman Ochre. This is a superior kind of yellow ochre.

Dutch-pink. Boil one pound of turmeric in a gallon of water, and add whiting to the clear liquor: the colour will unite to the whiting, which is then to be collected and dried. French berries may be used in the place of turmeric

Brown-pink. This is prepared by adding to a solution of alum, mixed with the infusion of some vegetable substance, a portion of potash. The colouring matter, along with the earth of alum, is thus precipitated.

Besides these, there are other colouring substances, which will be noticed hereafter, such as gall stones, French-berries, saffron, &c.

§ 6. Green. There are few colours that are as useful as greens; accordingly, it is the practice with artists, to form their greens by the mixture of blue and yellow colours. By varying these a vast variety of green tints may be obtained.

Verdigrease. This pigment is formed by corroding copper plates. See Copper. It is of a blueish green colour, but has no body, and does not stand. It is only used for very coarse purposes. It answers best when used in varnishes.

Distilled Verdigrease is an acetite of copper, for the preparation of which, see Copper. It is of a very light green, and is used chiefly for varnishes, and in colouring maps, &c.

Brunswick Green. See Brunswick Green.

Scheele's Green. This pigment is formed of arsenic and copper. It was discovered by Scheele of Sweden. It is prepared in the following manner: Dissolve two pounds of blue vitriol in about three gallons of boiling water, in a vessel capable of holding at least four gallons more. In another vessel boil together two pounds of pearl ash, and three quarters of a pound of *white arsenic*, in about two and an half gallons of water; boil it till the arsenic is dissolved or nearly so; then pour this last hot solution into the first while hot. A precipitate will form, which when collected, washed, and dried will be the Scheele's green, and will amount to about one fourth of the ingredients in colour. See Copper.

To make a fine Green. Pulverise in a mortar, equal quantities of verdigris and cream of tartar, to which add eight times its quantity of water; let it remain thus for eight days in a bottle, kept in a moderate heat. This solution is then to be filtered, adding thereto an eighth part of the weight of the verdigris of gum-arabic, keeping it over a gentle stove heat until the gum is dissolved; from this will be obtained a fine green, which will be rendered more clear and deep according to the degree of evaporation.

Green Pigments. Cheap paints of a green colour, with different shades, may be made by precipitating solutions of copper by whiting and potash.

Sap Green. This colour is the concreted juice of the *buck thorn berries*. The berries are expressed, and the juice boiled to dryness. It is never used in oil. It is employed chiefly in flower-printing and colouring prints, &c. The following particulars of the process for making sap green, may prove useful:

About a fortnight or three weeks before Michaelmas, take as many sloes as you please; mash them a little, and put them into a clean glazed pan; sprinkle them well over with powdered alum, and let them stand in a hot place for twenty-four hours; then pour upon them clean lye, and put it upon a fire, and give it a slow boiling, till a good quantity is boiled away; then take it off the fire; let it cool, and pour it through a cloth; what comes through, put up in a bladder, and hang it in the air to dry; afterwards keep it always hanging in a dry place, or in the chimney corner; and when you have occasion to use it, take as much as you want and dilute it with clear water: if it should turn too much upon the yellow, mix it with a little indigo.

Another finer Sap-Green. Take of blue lilies, that part of the flower which is of a a fine blue colour (for the rest is no use,) and stamp them well in a stone mortar; then put upon them a spoonful, or according to the quantity of the leaves, two or more spoonsful of water, wherein before has been dissolved a little alum and gum arabic, and work it well together in the mortar; then strain it through a cloth; put it into muscle-shells, and set them in the sun to dry. Or,

After you have proceeded as before, fling some powdered quick-lime over it, before you strain it through the cloth, and put it in muscle-shells. Or,

Beat the blue leaves of lilies in a stone mortar; strain them through a fine cloth into muscle-shells, and fling some powdered alum over; to one more than the other, in order to make the colours of different shades.

To prepare a fine Green Colour. Temper indigo and yellow orpiment with gum-water: grind it fine, and mix with it a little of ox or fish-gall, and you will have a pleasant green. You may shade it with indigo or sap-green, and heighten it with Dutch pink.

§ 7. Blue. Of blues, the principal are Prussian and Dutch blue, verditer, smalt, bice, and indigo.

Prussian Blue.—To make Prussian blue, four ounces of alkali are mixed with an equal weight of dried bullock's blood, and the mixture is exposed to ignition in a covered crucible. By this treatment a coal is obtained, which is afterwards lixiviated in water, filtered, and concentrated by evaporation. The liquor, formerly known by the name of the phlogisticated alkali, is now more properly termed prussiat of potash. On the other hand, two ounces of sulphat of iron and four ounces of alum are dissolved in a pint of water. The two solutions are then mixed, and a blueish powder falls down, which is rendered still more intensely blue by washing it with muriatic acid.

This is the process used in chemical laboratories; but another method is followed in the manufactories. The raspings of horns, clippings of skins, or other animal substances, are converted into charcoal, by heating them in covered vessels. Thirty pounds of potash are then mixed with ten pounds of this coal, and the mixture calcined in an iron vessel. After twelve hours ignition, the mixture acquires the form of a soft paste, which is poured out into vessels of water. The water is then filtered, and the solution mixed with another, consisting of three parts of alum, and one of sulphat of iron. See Iron.

To make a Vegetable Blue.—Gather a sufficient quantity of the common field *blue bottles* of the deepest colour, together with the cup of the flowers, which are to be dried a little upon a stove of a moderate heat. The flowers in this state (half dried) are to be steeped with gum arabic water, and the whole kneaded together; this paste is then to be placed between paper, and strongly compressed between boards. They are left in this state some days, when it is bruised in a stone mortar, adding thereto a small quantity of alum dissolved in water. It is then filtered, and the liquor thus filtered, is evaporated in a china vessel, and the residue at the bottom thereof is the finest vegetable blue.

Ultramarine.—This preparation is formed from the lapis lazuli in the following manner:

Calcine the *lapis lazuli* in a crucible; then grind it very fine on a porphyry. Mix up the powder with a paste made of wax, pitch, mastich, turpentine, and oil; and lastly, wash the paste well in clear water, to separate the colouring part from the rest, which precipitates to the bottom in the form of a subtile, beautiful, *blue* powder.

To know whether it be pure, if you buy any ready made; put a little of it in a small crucible, and on heating it red hot, if the powder keeps its colour, it is undoubtedly genuine: on the contrary, if any change be perceived, or any black spots appear, it is either spurious, or adulterated.

To prepare a blue Colour, little inferior to Ultramarine, from Blue Smalt.—Grind your smalt very fine, and proceed in every respect as you have been taught above, in preparing ultramarine.

To prepare a Blue Colour from Silver.—Hammer silver thin; neal it thoroughly, and rub it a little over with quicksilver; then put a little of the sharpest distilled vinegar, in which you have dissolved some sal-ammoniac, into a glass; hang the silver slips over it, so as not to touch the vinegar: cover it very close, and put it into a warm place, that the fumes of the vinegar may raise on the silver: it will form a very beautiful blue, adhering to the slips; wipe it off into a shell, and hang the silver slips over the vinegar again, well closed; repeat this, until all the silver is corroded.

A Blue of Egg Shells.—Take egg shells, calcine them in a crucible, beat them to a fine powder; put that into a copper vessel, and pour vinegar over it; which set into horse-dung for a month, and you will have a delightful blue.

To make Venetian Sky-blue.—Take of quicklime one pound, mix and work it with sharp white-wine vinegar into a dough; let it stand for half an hour, and when hard, pour more vinegar to it, in order to make it soft; when done, add to it two ounces of good pulverized indigo; mix them well together; set it in a glass vessel for twenty days under horse-dung, after which time see whether it is of a fine colour; if not, set it again, as long as before, in the dung, and it will then come to its perfection.

To prepare a Blue Colour from Verdigrise.—Take sal-ammoniac and verdigrise, of each six ounces; mix them well together with aqua-kali, into a paste, put this into a phial, and stop it close; let it stand for several days, and you will have a fine blue colour.

To prepare Blue Tornisel, or Turnsol, a beautiful Colour.—Take sloes, before they are full ripe, beat them into a paste, which put in a clean earthen pan: take another earthen pan, put into it a quart of water, three ounces of quicklime, and a quarter of an ounce of verdigrise, and one-fifth of sal-ammoniac; let these things

soak in the water until it is tinctured of a green colour. In twenty-four hours the lime and verdigrise will be sunk to the bottom: then decant off the water through a cloth, into another earthen vessel, add to it the paste of sloes, and let it gently boil over a slow fire; when cold, it will be of a fine sky blue; then pour that liquid into a clean pan through a cloth; set it on ashes; and when it begins to be of a thickish substance, then put it up in a bladder, and hang it up to dry. You may also dip clean soft linen rags into it; dry them in the shade; and when dry, repeat it again for three or four times; these preserve in paper; and when you have occasion to use it, soak one of these rags in a little fair water, and you will have a beautiful blue colour.

Ultramarine Ashes.—This is the residuum after washing the lapis lazuli, in which a portion of the ultramarine still remains. It is not so bright as ultramarine.

Verditer.—This is a blue pigment, made by adding lime, chalk, or whiting, to the solution of copper in aquafortis. It is also made from blue vitriol.

Smalts Blue,—Is glass coloured with zaffre, or oxyd of cobalt. When finely pulverized, it makes a good colour. See Cobalt.

Bice,—Is prepared from the *lapis armenius* It bears the best body of all the bright blues in common use, but it is the palest in colour. It is said to be only smalt more finely levigated.

Dutch Blue.—See Litmus and Archilla.

Sanders Blue.—This is the same as verditer, as above noticed.

Indigo—Is but little employed in painting, either in oil or water. It requires no other preparation than that of being washed over, before it is used. See Indigo.

§ 8. Purple. The only simple colour of this kind is colcothar of vitriol. If a solution of tin be added to a decoction of logwood, a purple coloured cake will be obtained.

§ 9. Brown. The chief brown colours are, bister and brown pink. Bister is the finer part extracted from the soot of burnt wood. It is much used also for sketches in water colours.

Cologne Earth.—This is a mineral substance of a dark blackish-brown colour. It is a very useful colour; though what is generally sold in the shops for Cologne earth, is an artificial mixture of several colours.

Raw Umber—Is a native ochrous earth, of a light brown.

Burnt Umber.—This is the last mentioned colour, calcined in the fire.

Asphaltum.—This colour is used in oil, and is of a very rich dark brown.

COMPOST, see Agriculture and Manure.

CONDUCTORS, are long rods made of iron or other metal, employed for protecting buildings from the effects of lightning.

The utility of conductors is universally acknowledged, yet it has not been ascertained, till within these few years, whether pointed or blunt ones were the most proper: the former, however, are now decidedly preferred, in consequence of several experiments, made under the inspection of the Royal Society.

The experience of every year convinces us that metallic conductors, or lightning rods, are not certain safeguards against lightning: it is of infinite importance, therefore, to state a certain mode by which all *possible* danger may be avoided; this we are enabled to do from the directions given by the late G. C. Morgan, in his lectures upon electricity; Norwich, 1794.)

The foundation of each partition wall of the house must be laid on a strip of lead; or the lead must be fastened to the sides of them. These strips must be connected, and their dimensions not less than one-fourth of an inch thick, and 2 inches wide. A perpendicular strip on each side of the house, should rise from this bed of metallic conductors to the surface of the ground: there a strip should be continued around all the house, and carefully connected with water pipes, &c. The strips on the sides of the house should then be continued to the roof, where the method of guarding the bottom must be imitated. The top is to be surrounded by a strip, whose connection should spread over every edge and prominence, and hence must continue to the summit of each separate chimney.

The chimnies in particular must be protected; for Mr. Morgan was witness to a case in which a house was guarded, in most respects, according to the method just described: but from the chimnies having been left unprotected, the lightning consequently struck one of them, where its rage terminated; but the tumbling of the chimney into the roof was attended by serious consequences. By guarding the house, we make it of all objects, that which is the most likely to become the circuit of a cloud; and consequently should be careful that no interruption divides the conductors, or the havoc will probably take place.

The expence of a conductor, erected according to the plan described, may be considerably lessened, by making a proper use of the leaden pipes and copings which belong to most houses; no other skill being requisite, than that of fastening the strips of lead, so that they may be secure, and at the same time be connected with each other.

Ships may be also easily protected. One strip of metal should surround the deck; another should be fastened to the bottom, or the side of the keel; these strips should be connected with others which embrace the ship in different parts.

If the vessel be copper-bottomed, nothing more is necessary than to connect the metal which surrounds the deck with the copper; but in both cases, a separate strip should pass from the rest of the strips to each mast; no injury can then possibly happen below deck. This is a circumstance of considerable importance; for the conductors which are usually designed for the masts, are moveable, and injury has often been the consequence of neglecting to place them in their proper situation.

The protection of the masts must be managed by extending a metallic body along the stays to as great a height as possible. Chains are frequently employed for this purpose; but strips of lead are cheaper; they are not separated by any interruptions; they are not so liable to injury from the weather and salt water as iron is, and, might be fastened without annoying any necessary movement.

COPAL. Copal, improperly called gum copal, is a hard, shining, transparent, citron-coloured, odoriferous, concrete juice of an American tree, procured from natural exudations, but which has neither the solubility in water common to gums, nor the solubility in alcohol common to resins, at least in any considerable degree. By these properties it resembles amber. It may be dissolved by digestion in linseed oil with a heat very little less than sufficient to boil or decompose the oil. This solution, diluted with oil of turpentine, forms a beautiful transparent varnish, which, when properly applied and slowly dried, is very hard, and very durable. This varnish is applied to snuff-boxes, tea-boards, and other utensils. It preserves and gives lustre to paintings, and greatly restores the decayed colours of old pictures, by filling up the cracks and rendering the surfaces capable of reflecting light more uniformly. See VARNISH.

COPPER. Copper is a malleable and ductile metal of a pale-red colour with a tinge of yellow.

The ores of this metal are very numerous, and may, with most convenience, be arranged under the eight following varieties.

Var. 1. Native copper.

Its colour is a clear copper-red, often tarnished, externally yellowish, blackish or greenish. It occurs in mass, disseminated, in leaves, in rolled pieces, in grains, capillary, filiform, moss-like, dentritical and crystallized.

It occurs in veins and beds in quartz and granite, in slate, porphyry, serpentine, hornstone and limestone; accompanied by various other ores of copper, particularly the red oxyd, malachite and copper pyrites; with galena, horn-silver, native silver, calcareous spar, heavy-spar and fluor.

It is very generally, though not often abundantly, diffused. The finest specimens come from the Tourinski mines on the eastern side of the Uralian mountains, from Herrngrund in Hungary, from Saxony, the Hartz, Fahlun in Sweden, and Cornwall. It is said to be remarkably abundant in Japan and Brazil, and to contain a considerable proportion of gold. It is also procured in quantity from the Copper-mine river within the Arctic circle in America.

Var. 2. Oxyd of Copper.

Sp. II. Ruby Copper. *Florid red Copper ore*, Kirw. *Roth Kupfererz*, Werner. *Cuivre oxyde rouge*, Hauy.

Of this species there are the following varieties.

Var. 1. Lamellar R. C. *Blattriges R. K.* Werner.

Its colour is cochineal-red, inclining sometimes to lead-grey; when crystallized it is of a full carmine-red. It occurs in mass, disseminated and crystallized.

It is met with chiefly in veins, and appears to be peculiar to primitive mountains: the substances with which it is accompanied are native copper, malachite, and brown iron ochre; sometimes mountain green, copper pyrites and other ores of this metal, also quartz, calcareous and heavy spars.

It is found in Cornwall, in Hungary, Saxony, the Hartz, Siberia, Peru and Chili.

Var. 3. Sulphuret of copper.

Its colour is dark lead-grey passing into blackish grey, it often presents a superficial steel-coloured tarnish. It occurs in mass, disseminated, or crystallized.

It occurs in veins in slate and some other of the newest primitive rocks, and in beds in the transition and floetz-rocks.

It is accompanied by copper pyrites, galena, manganese, spathose iron, quartz, heavy spar and fluor; also, though rarely, with malachite and azure copper. When it contains a notable proportion of silver, it is worked as an ore of that metal, and will accordingly be mentioned again under silver.

It is found in Cornwall and Ayrshire, and in many parts of the continent.

Var. 4. Arsenicated copper.

Its colour is intermediate between silver-white and brass yellow. It occurs in mass or disseminated. Internally it has a slight metallic lustre. Its fracture is small and fine-grained, uneven. It yields easily to the knife, is brittle and readily frangible.

It occurs in veins and beds in primitive mountains, and is generally accompanied by copper pyrites and vitreous copper. It is found in the copper mines of Cornwall, Saxony, Hessia, Silesia, Hungary, Siberia, and Chili in South America.

By its colour and arsenical odour when heated, it is distinguished from the sulphurets of copper.

Var. 5. Carbonated copper.

Its principal colour is azure-blue, which passes into Prussian-blue, indigo blue, and rarely to smalt-blue.

It is opake, slightly stains the fingers, and is easily frangible.

In borax it dissolves with vehement ebullition forming a green glass.

Azure copper occurs in the newer primitive rocks, but more commonly in floetz mountains. It accompanies other ores of copper, especially malachite, grey copper and copper pyrites. The most beautiful specimens come from the Bannat in Hungary and Siberia. In the Tyrol it is found in sufficient plenty to be manufactured into the pigment called mountain-blue.

Var. 6. Arseniat of copper.

Its usual colour is deep sky-blue, passing into Prussian-blue; it is also found of a bright grass-green, passing into apple-green, greenish-white, and bluish-white.

It occurs in the Muttrel mine, adjoining to Huel Gorland, accompanied by the same substances as the preceding species.

Var. 7. Phosphat of copper.

Its colour externally is greyish-black, internally between emerald and verdegris-green.

It is found loose in the bed of a river at Remolinos in Chili, and elsewhere, though rarely, in Spanish South America.

Reduction of the Ores. The reduction of copper ores in the large way is on the whole a very simple business, being little else than a succession of roasting and reducing processes of the simplest kind, till the metal acquires the desired degree of malleability and purity. It is to be observed, that both arsenic and sulphur adhere to copper with great obstinacy, even long after it has assumed the appearance of a pure regulus, and even in very small proportion they make the metal brittle, hard and difficult to work.

There are scarcely two works in which precisely the same order is observed in the different reducing processes (supposing the quality of the ore to be the same) and as the manufacturer is generally satisfied with that which has long been established, and is attended with ordinary success, he seldom enquires whether the labour may be shortened or the expence diminished.

The sulphuret of copper which is obtained in such vast quantities at the Parys mine in Anglesea, is wrought into rough copper in the following manner. The ore is dug up in large pieces (being mostly obtained by blasting,) and is first broke into smallish lumps by the hammer, chiefly by women and children, and put into a kiln from which proceeds flues that open into a very long close pent-house gallery to collect the sulphur. The kiln is covered close, and a little fire is applied to the mass of ore in different places, whereby the whole is gradually kindled. The sulphur then rises in vapour to the top of the kiln, and thence through the flue into the long gallery, where it slowly condenses, and is afterwards brushed out and further prepared for sale. The mass of ore when once kindled continues to burn of itself with a smouldering heat for about six months, during which time the sulphur-chamber is cleared out four times, after which the ore is sufficiently roasted. The old sulphur-chambers are on a level with the kilns and of the same length and height, or in fact they are a prolongation of the kilns: but the more modern and improved chambers are like lime-kilns, the ore being at the bottom, and the sulphur subliming at the top, with a contrivance to take out the roasted ore, and thus to keep up a perpetual fire.

The richest part of the roasted ore is exported without further preparation, but the poorest part is smelted on the spot. It still contains a vast quantity of sulphur and other impurities. The smelting houses are a range of large reverberatory furnaces, thirty-one of which are under the same roof, ranged side by side, in a single long row. They are all air furnaces, the chimneys of which are 41 feet high, which causes a most powerful draught through them. The fuel is coal, which is burned on a grate at the anterior part of the fur-

nace, and the flame in drawing up the chimney passes over the bed of the reverberatory, into which is put 12 cwt. of the roasted ore, previously mixed with a small portion of coal dust. The ore is here melted and reduced into a very impure regulus, and when sufficiently fused, it is drawn off through a plug-hole into earthen moulds. A single charge of the furnace, or 12 cwt. yields half a hundred of rough copper, which by further purification affords about 50 per cent. of pure malleable metal. The furnaces work off a single charge about every five hours.

The copper furnaces inCornwall are also of the reverbatory kind. The ore when drawn up from the mine is first broken into pieces no bigger than a hazel-nut, which operation is called *cobbing*, and the better sort is picked out by hand. The reduction begins by the process of roasting in large reverberatory furnaces 14 feet by 16, the bottom or bed of which is made of fire bricks, and covered to the thickness of about two feet with silicious sand, which runs together by the heat into a semi-vitrified mass. The chimney is from 40 to 50 feet high, which causes such a powerful draught that the arsenic and sulphur, separated during the roasting, pass almost entirely through the chimney into the open air, none of it being collected as at Anglesea. The ore is spread over the bottom of the furnace, about a foot thick, being thrown in through a kind of funnel or hopper just above. The fuel is Welsh coal; which, as usual, is burnt at the interior part of the furnace, and its flame draws over the surface of the ore in its passage to the chimney. In this furnace, which is called the calcining furnace, and is the largest of all, the ore is roasted without addition with a dull red heat for 12 hours, and is frequently in that time, stirred with a long iron rake, introduced through a hole at the further end of the reberveratory, to expose fresh surfaces to the action of the flame. The ore is not melted here, but, when roasted sufficiently, it is carried to another furnace, exactly similar to the former, but smaller, that is, about 9 feet by 6, and here it receives a fusing heat, but still without any addition, except that when the slag does not rise freely, a little calcareous sand is thrown in. At the end of every four hours the slag is raked out; it is then of the consistence of soft dough, and is ladled into oblong moulds, and a little water is sprinkled upon it to make it sink down, after which the moulds are quite filled with it, and when cold it makes hard solid blocks of slag, about 14 inches long, and 12 deep and broad, which are used for building. After the slag is raked off, a fresh charge of calcined ore is let down into the reverberatory, and the copper is tapped off by a hole, in the side of the furnace, which, before the fusion, had been stopped up with a shovel full of wet clay, mixed with about a fourth of new coal, which prevents the clay from hardening too much, so that the whole may readily be opened by an iron pick.

The rough copper as it runs from the furnace is conveyed by a gutter into a large kind of bucket suspended by chains in a well, through which a stream of water is passing; and here, in falling into the water, the metal is granulated, which takes place without explosion or danger, and it is then drawn out by raising the bucket.

The copper is still however extremely impure, though apparently in the metallic state, being grey and perfectly brittle, and still mixed with arsenic and sulphur, to separate which, is the work of several subsequent processes. It is then remelted and granulated twice more or oftener, each time, throwing up a slag in the furnace, which is removed before the plug-hole is tapped; but as this slag contains some copper, it is not cast into moulds as the first, but worked over and over again with the fresh charges of calcined ore. The number of fusions and granulations is entirely determined by the nature of the ore. The granulated mass is then melted and cast into pigs, which have a blistered appearance on the surface,and are broken up and roasted for one or two days, in a low red heat, and again melted and roasted as before for several times till the metal is considerably purer, and at last is cast in oblong iron moulds about 14 inches in length, when it is removed to the *Refining Furnace*. Here it is again melted with the addition of a little charcoal, till it is brought to a sufficient purity to bear the hammer, and is now good saleable copper.

It is observable, that in the former process when the crude and brittle metal is cast in sand in the form of large pigs or ingots, the best part of the copper rises to the surface, and when cold may be knocked off with a hammer, forming a brittle crust about three-quarters of an inch thick, of a grey colour and of a steel-like fracture.

Thus, by a series of successive calcinations and fusions, in the simplest manner possible, the common copper ores are freed from arsenic, sulphur, and earthy matters, and gradually brought to the state of malleable copper. Where a va-

riety of ores from different places and of different species are brought to the same smelting-house (which is the case in many of the houses at Swansea and different parts of the Bristol coast) much technical judgment is exercised in sorting the ores and distributing the charges for the furnace, in such a manner that the more fusible will assist the reduction of the refractory, and the poorer will be made more worth working by the addition of a portion of the richer ores, and the like.

Before the copper is converted into plates or bars, the pig of metal, is made red hot, when it is closely beaten together under the hammer, and cut into pieces of the most convenient length, for the purpose wanted, by shears moved by a wheel. Again, those pieces are conveyed to the furnace, when they become red-hot as at first. One of the pieces is carried, at a time, to the flatting mill; a machine, not much unlike the rolling press, of a copper-plate printer. The two cylinders are of steel, case-hardened and secured, within a frame of iron. A man stands on each side, and, while the two cylinders revolve, each in a contrary direction, one of them lifts up the piece of red hot copper with a pair of tongs, and thrusts it between the cylinders, the other man on the opposite side securing it with his tongs, as it passes through. This he lifts back again over the upper roller, to the first man, who, by the assistance of a strong screw, diminishes the distance between the two cylinders, in order to widen and compress the plate still more; when it is conveyed a second time between them. This screw is turned for the same reason every time before the plate passes between the cylinders, and thus, by the most simple process imaginable, the plate is gradually reduced as thin and broad as the workmen desire.

By means of a similar machine, the copper is wrought into bars instead of plates, of any form or thickness, with equal facility. For the latter purpose, the smooth surface of both the cylinders, are alike indented with eight, ten, or more distinct grooves, all which differ from each other in width and depth. The series commences with the largest groove, encircling one end of the cylinder; the next in point of size succeeds, and thus they diminish gradually to the other extremity of the series, which terminates with the smallest groove. The piece of copper being heated as before, to a fiery redness, the workmen force it between the first or largest groove of the adjusted cylinders, where it receives either the round or angulated form of the groove, from the compression of both the cylinders, as readily as wax in a common mould. Should it be necessary, the bar is conveyed in like manner, progressively through the second, third or fourth groove, or through the whole series, till it is reduced to the thickness wanted, the length being increased, as the bulk diminishes.

The copper, after receiving its proper form in the flatting mills, and cooling, is of a dusky black, or iron colour, and in order to communicate to it that lively hue which is commonly understood to be the true complexion of this metal, the plate or bar is heated again for the last time in a furnace, and when red hot is plunged into a recess filled with a saline liquor, where it assumes that colour in a few moments, and being withdrawn, the copper is put aside as being finished for exportation.

The subsequent operations, whereby the ingots or pigs of malleable copper are formed into wire, nails, bolts, and an infinite variety of maufactured articles, will be treated on under their respective heads. It may be necessary to observe, that the working renders the metal much more uniform, close, and ductile, but this requires to be frequently alternated with annealing at a full red heat, to prevent the metal from cracking under the powerful pressure to which it is exposed.

In the reduction of the copper ores of Neusol in Hungary, lead is used in the refining part of the process, in the following manner: the rough copper is spread on the bed of a furnace, and when it has been six hours in fusion, some lead, in the proportion of from 6 to 8 per cent. of the copper, is thrown in, which immediately begins to vitrify and to form a thick scoria along with the impurities of the copper, which is scummed off successively till the whole is exhausted and the copper remains fine and clear. This process lasts from 10 to 12 hours, with 50 quintals of raw copper. The scoriæ retain a portion of copper, which makes it answer to work them again.

The power which the vitrified oxyd of lead has to scorify all metals, except gold, silver and platina, is amply shewn in the process of *Assaying*, and hence it must happen that in refining, some of the copper becomes oxidated together with the lead; but the same process of assaying shews that copper requires a large portion of lead for this purpose, and therefore the latter metal in so small a proportion as 6 to 8 per cent. is probably a most useful addition where not too expensive.

For of all the common imperfect metals, copper is that which scorifies and oxidates with most difficulty when in fusion, and therefore the same method, with some little variety, may be practised to separate lead and tin (for example) from copper, as any or all of these metals from silver or gold; care being taken in the former case not to carry the scorification beyond what is necessary to separate the more easily oxidable metals from the copper, which then remains in the metallic state. This will be further noticed in the succeeding article of *Alloys of Copper*, and the purification of bell-metal. After the greater part of the lead has been worked off as often as is judged necessary, the remaining copper must be kept for a while longer in fusion, to throw up the last portions of lead that may adhere. In assaying gold or silver the total expulsion of the lead is known by the fine metal becoming at once brilliant on the surface, but in refining copper this appearance can never take place, as the copper itself always forms a thin oxyd on its melted surface; and therefore, to judge whether it is pure, the workman dips a polished iron rod in the melted mass, and draws out a portion of copper adhering to it; which, if pure, immediately falls off when the rod is dipped in water. The colour of the scoria is also another test. While the copper remains impure and alloyed with iron, sulphur, &c. the vitrified oxyd on the surface is black or of a dirty brown, but the scoria of pure copper is red, and also is readily separated from the iron when cold, leaving no stain behind.

The plates of fine red copper, called *Rosette Copper* are made in the following way. When the refined copper is found, by the way just mentioned, to be sufficiently pure, the surface of the melted metal is well scummed and suffered to cool till it is ready to fix; at which time a workman brushes it over with a wet broom, which immediately fixes the surface and causes a thin plate to separate from the still fluid metal below. This plate is taken off and thrown into water, where it takes a high red colour, and the same process of wetting the surface is repeated with the remaining fluid metal successively, till the whole is reduced to these thin irregular plates.

A considerable quantity of copper is obtained from the springs of native sulphat of copper or blue vitriol, which are found in most copper mines or flow from hills containing this metal. To obtain it, the vitriol water is pumped up into large square open pits, two or three feet deep, made with rammed clay, into which is thrown a quantity of refuse iron of any kind, and suffered to remain for a considerable time, during which the iron is dissolved, displacing, by superior affinity, the copper which is precipitated in the form of a brown mud. When the water is thus exhausted of its copper, the pits are raked out, and the oxyd collected from them is simply dried in the sun. It is then fit for reduction in the reverberatory furnaces in the usual manner. This is by far the richest material employed; for, though containing some clay and iron mixed with the copper, it yields on an average full 50 per cent. of pure metal, and therefore it is seldom smelted by itself, but mixed with the poorer ores, some of which contain no more than 5 per cent. of metal.

Many of the finest copper ores contain so much silver as to make it worth while to extract this last metal by a separate operation, which will be described under the article *Silver*. In all the different roastings and reductions necessary to bring the copper to purity, the silver remains united with it.

Acetous acid acts upon copper, when oxydated, and dissolves it with ease into a fine green liquor, readily crystallizable. There is with this, as with many of the other cupreous salts, a distinct state of *sub-acid* and of saturated salt. Both the sub-acetite and the acetite of copper are the products of a manufacture, carried on to a considerable extent in the South of France, and therefore require a fuller description: the sub-acetite being the common verdigris of the shops, and the acetite, being the crystallized, or distilled verdigris, as it is called.

This manufacture in its present somewhat improved state, is thus described by Chaptal, as carried on at Montpellier.

The materials for this manufacture are, 1st. Any refuse matter of the ripe grape, the stalks, seeds, &c. but more particularly the *marc* or the cake that remains in the wine-press after the greater part of the juice has been extracted. This, when fermented, produces the acid requisite to corrode the copper. 2d. Plates of copper of convenient size and previously hammered well to smooth the surface, in order that the corroded portion may be conveniently detached, without which preparation too much of the copper would peel off in the scales, without being thoroughly penetrated by the acid.

The marc of the grape, which may be kept for a good while by being close packed in casks, is first fermented, simply by being laid loosely in a large barrel, moistened with water (or better with

wine) and set in a warm airy place. After awhile, sometimes in a day, at other times in two or three weeks, it heats, swells, and gives a strong smell of vinegar, and when the fermentation subsides it is fit for use. The richer the grape juice of course the better is the marc, and the more perfect will be the subsequent fermentation, on which much of the quality of the verdigris depends. Hence it should not be too closely pressed, or, if poor, it should be moistened with a little ordinary wine. To determine when the marc is sufficiently fermented, a small copper plate is buried in it for twenty-four hours, and if fit, the plate will come out covered uniformly with a green crust. The plates are then all heated scorching hot over a pan of charcoal, and laid regularly in earthen pots with a layer of the fermented marc at bottom and at top, and interposed between each plate. The pot is then loosely stopped with straw, and the whole left at rest from ten to twenty days. These earthen pots (the same in which the marc is fermented) are about 16 inches high, and 14 in diameter, and the mouth 12 inches. Each holds about 30 or 40 pounds of copper plate, with the requisite quantity of marc. When the plates are used for the first time, they are previously prepared, by being rubbed with a rag dipped in a solution of verdigris in water, and suffered to dry. Without this the first produce of verdigris is apt to be black. This is not required a second time.

The earthen pots are emptied when the marc begins to whiten, and if the process has gone on well, the copper plates are found covered with a green crust interspersed with distinct silky green crystals. They are then taken out (the marc being thrown away) and set on end face to face on wooden racks in a cellar: and when dry they are dipped in water (formerly in wine) and again set to dry, and this is repeated once a week for six or eight times, which makes them swell, and in every way improves and encreases the crop of verdigris, which is finally scraped off with a knife without difficulty. Every pot yields about five or six pounds of rough verdigris, and the plates, after this is separated, will serve again repeatedly till they are corroded quite through.

The verdigris is sold by the maker in the rough state, and is further prepared by being well ground in wooden mortars and exposed to the air on skins till sufficiently dry, in which process it loses nearly half its weight. The whole of the manufacture of the rough verdigris is a part of household business in the wine-farms about Montpellier, and is generally done by the women. It requires little attendance, and no other capital than the expence of the copper plates and earthen jars.

Verdigris thus prepared may be considered as copper oxydated by the action of the acetous acid of the fermented materials, united with water, and a small portion of undecomposed acetous acid, together with part of the extractive or mucilaginous matter of the marc. In this state it is insoluble, or nearly so, in water. The colour is a fine green, and it is used more largely as a pigment than any other cupreous preparation.

Verdigris is however completely soluble in an additional portion of vinegar, and the result is the perfect *acetite of copper*, a beautiful crystallizable salt, sold at a a very high price in the shops under the name of *distilled verdigris*. It is prepared from common verdigris in Holland and France, and Montpellier; the process which is followed at the latter place is very simple, and is thus described by the same accurate observer. Common vinegar is first distilled in a copper alembic, which seems to be a process constantly going on in the small way in most of the vintage farms in the neighbourhood. This is put with common verdigris into a copper boiler, and, when a hot saturated solution is made, it is strained and let off to another copper evaporating vessel, where it is boiled down till a crust of the salt appears on the surface. A light frame of sticks in cross-bars is then sunk in the liquor and the fire put out. On cooling, the acetite of copper crusts around the sticks in most beautiful clusters of rhomboidal crystals of a fine deep blue-green colour. When these are dried and finely powdered, they form a green pigment of great beauty and value. It requires about three pounds of verdigris to make one pound of the crystallized acetite. The part which remains undissolved in the vinegar consists of an imperfect oxyd or acetite, which used to be thrown away, but as Chaptal has observed, when moistened occasionally with vinegar, and exposed to the air, it yields a fresh quantity of verdigris, and is then readily soluble in vinegar.

According to Chaptal, two kinds of verdigris are particularly distinguished in France, that of Montpellier, and that of Grenoble. The latter is prepared in a different manner from that already described, no fermented refuse of the vintage being here used, but the process is chiefly to dispose plates of copper in a proper room, and to moisten them repeatedly with distilled vinegar till the surface

is sufficiently oxydated and converted into verdigris. The former is somewhat cheaper, and is preferred in painting, the latter is more used in dyeing.

The uses of copper, in all its various states, are almost endless, and only, if at all, inferior in number to those of iron. Besides the variety of uses for which copper and its alloys are employed in the metallic state, various pigments and dyeing materials are obtained from its salts, and the oxyd is used to give an emerald green to coloured glasses and enamels. See COLOUR-MAKING, DYEING and GLASS.

All the salts of copper are more or less poisonous, producing violent nausea, and the severest pain and inflammation of the alimentary canal. Yet from the sudden vomiting which they excite, a large dose may be given with safety, and this is sometimes used when it is necessary immediately to empty the stomach.

COPPER, *Alloys of.*

The alloys of copper (that is, those in which this metal predominates) are more numerous and more important in the arts, than those of any other metal. Many of them are perfectly well known, and have been in use from very ancient times; of many the exact composition, and particularly the mode of preparing, are kept as secret as possible; for, even when the precise composition of an alloy is found by chemical analysis, it may often be extremely difficult to produce a mixture by common methods, which shall have exactly the same shade of colour, the same malleability, texture, susceptibility of polish, or some other excellence, which, perhaps, a mere accident has discovered to the possessor. Another circumstance of infinite consequence to the manufacturer, is the ordinary state of purity of the materials he employs, and this alone will account for the great superiority of one manufacture over another; thus, the Swedish copper is commonly purer than the British, and makes more malleable alloys, the English tin better than most of the foreign, and the like.

The principal objects of alloying copper, appear to be to render it less liable to tarnish, and especially to be acted on by common animal or vegetable substances, (which, when it is used for culinary purposes, is of extreme importance): to make it more fusible, and harder, and able to take a higher polish; and to alter its colour either to a golden yellow or a silvery white. All these objects are attainable by different alloys.

Copper with Gold, Silver, and Platina.

These are seldom if ever used in the proportions in which they would be alloys of copper, being much too costly for any purpose of manufacture, considering the great deterioration of the more valuable metals; with this exception, however, that a very small portion of silver much improves the composition of the alloy of copper and tin, when used as bell-metal, or speculum-metal. Copper is used largely as an alloy of gold and silver, and it is often plated with one or the other. This subject we shall refer to these metals respectively.

Copper with Arsenic.

Arsenic has, beyond any other metal, the effect of whitening copper, but as it is readily evaporated in fumes at less than a red heat, and therefore at a temperature much below the melting point of copper, some management is required to effect a combination of the two. It seems, some put the arsenic in a small crucible, invetting it over the smelted copper and forcing it down to the bottom, holding it there till all the arsenic has passed through. By repeating this several times, the copper may probably be more fully saturated with arsenic, observing each time to give no more heat than requisite.

This alloy is quite white, of a very close texture, but perfectly brittle.

Vauquelin has observed, that when equal parts of silver and copper are alloyed (which by themselves make a pale yellow mixture) the addition of so little as 2 of arsenic to 100 of the alloy gives a perfect whiteness, whilst the ductility and malleability remains. Beyond 5 per cent. of arsenic the alloy begins to be brittle, without increasing in whiteness.

Arsenic is used in small quantity in some of the more compound white alloys of copper, particularly in speculum-metal.

Copper with Iron.

These only unite when the iron is in small quantity. The alloy is grey, hard, and somewhat brittle.

Tutenag is a white alloy of copper, zinc, and iron, according to Keir, which is very hard, tough, and sufficiently ductile to be wrought into various articles of furniture, such as candle-sticks, &c. which take a high polish, and when made of the better sort of tutenag are hardly distinguishable from silver. The inferior kinds are still white, but with a brassy yellow.

The Chinese *Petong* is another fine, white, malleable alloy of copper, the composition of which is not exactly known, but it contains a small portion of silver. Neither of the above metals are imitable by the common processes.

Copper with Lead.

Copper with about a fourth of its weight of lead forms *pot-metal.* The ancient Roman pot-metal, according to Pliny, was composed of 100 of copper, 2 of lead, and 2 of tin. The same ingredients, but with more of the two latter, were the materials of many of the ancient Greek and Sicilian coins.

Copper with Zinc.

Copper nearly saturated with zinc, that is, in which the latter makes about a fourth (more or less) of the mixture, forms *brass*, the most important of all the alloys of this metal, and which has been described under that article. With a much less proportion of zinc the colour of the alloy approaches very nearly to that of gold, and the malleability increases. Mixtures chiefly of these two metals are used to form a variety of yellow or gold-coloured alloys, known by the names of *Tombac, Manheim or Dutch Gold, Tinsel, Similar, Prince Rupert's Metal, Pinchbeck,* &c. but the precise composition varies according to the fancy or the experience of different manufacturers. The Dutch gold may be beaten out into extremely fine leaves, which, when fresh, have nearly the brilliancy of gold-leaf, and are used as a cheap imitation of it, but they tarnish very soon. The mixture may be made either by directly melting copper and zinc, or, by mixing brass and copper. In either case, the copper should be melted first, and the zinc added afterwards; the whole stirred together with wood, covering it with a little charcoal, and poured out immediately, to prevent the loss, by the burning off of the zinc.

Several direct experiments on the union of copper and zinc, in different proportions, were made by Margraaf. In all, the copper was the purest Japanese, and the mixture was made in the way abovementioned. With 8 drams of copper, and as much zinc, much of the latter unavoidably burnt off, and the alloy, only weighed 12, instead of 16 drams—the mixture was hard, brittle, yellow, and of a radiated texture. With 16 drams of copper, and 8 of zinc; the loss by burning, was only $\frac{1}{4}$ of a dram. The alloy was softer than the last, still radiated, yellow, and began to be a little malleable. From this, successively diminishing the proportions of zinc, the alloy became softer, more malleable, and of a colour, more and more approaching to gold: and at last, with 11 or 12 of copper, and 1 of zinc, the finest golden tombac was produced. According to Wiegleb, the Manheim gold is made by melting separately, 3 parts of copper, and 1 of zinc, mixing them, covering with charcoal, stirring with a stick, and cooling immediately. These proportions scarcely differ from those of some kinds of brass. Beaumé gives for the same metal, 4 of copper, and 1 of zinc, whence it is obvious, that the proportions are quite arbitrary; but it appears that the alloy is not made, as brass is, by cementation, but by simple mixture of the metals. A very small quantity of tin is sometimes employed; but this metal has the disadvantage of remarkably diminishing the malleability of copper and its alloys. A fine malleable tombac is made, however, with 16 of copper, 1 of zinc, and 1 of tin. An alloy of 12 of brass, and 1 of tin, is scarcely malleable.

A kind of tombac, is the material, of which a large proportion of the Roman coins were composed. Klaproth, on analyzing several, struck during the first century of the emperors, found them all to consist either of pure copper, or of copper and zinc; in which the latter metal made generally, from a fifth to a sixth of the mass. A little tin and lead were found in some, but in such small proportion as to appear only an accidental impurity.

Copper with Tin.

The alloys of copper and tin, are extremely important in the arts, and curious as chemical mixtures. They form in different proportions, mixtures, which have a distinct and appropriate use. Tin added to copper, makes it more fusible, much less liable to rust or corrosion, by common substances, harder, denser, and more sonorous. In these respects, the alloy has a real advantage over unmixed copper; but this is, in many cases, more than counterbalanced by the extreme brittleness, which even a moderate portion of tin imparts, and which is a singular circumstance, considering how very malleable both metals are before mixture, and the remarkable softness and ductility of tin.

The sensible qualities of the different mixtures, are the following:—Copper alloyed with from 1 to about 5 per cent. of tin, is much harder than before, the colour yellow, with a cast of red, and the fracture granular. It is still considerably malleable. An alloy, in which the tin is from one-tenth to one-eighth of the whole, is hard, brittle, but still a little malleable, close-grained, and yellowish-white.—Where the tin is as much as one-fourth of the mass, it is entirely brittle, and continues so in every higher proportion. The yellowness is not entirely lost till the tin is above seven twenty-thirds of the whole.

Copper, or sometimes copper with a little zinc, alloyed with as much tin as will make from about one-tenth to about one-

fifth of the whole, forms an alloy which is the principal, and often the only composition for bells, brass cannon (so called) bronze statues, and several smaller purposes; and hence it is called *Bronze*, or *Bell-Metal*, (always observing, that there is no perfect uniformity in the different alloys under these names, either in the proportion or the actual number of ingredients) and it is excellently fitted for these purposes, by its hardness, density, sonorousness, and fusibility, whereby the minute parts of hollow moulds may be readily filled, before it fixes in cooling. For cannon, a lower portion of tin seems to be used. According to Dr. Watson, the metal used at Woolwich, is 100 parts of copper, and 8 to 12 of tin. Hence, it still retains some little malleability, and of course, is tougher than with more tin. Bronze cannon, are much less liable to rust than those of iron; but in large pieces of ordnance, by very rapid firing, the touch-hole is apt to melt down, and spoil the piece. On account of the sonorousness of bronze, these cannon give a much sharper report than those of iron, which, for a time, impairs the hearing of the people that work them. A common alloy for bell-metal, is about 10 of copper to 20 of tin; or, where copper, brass, and tin are used, the copper is from 70 to 80 per cent. including the portion contained in the brass, and the remainder is tin, and zinc. The zinc certainly makes it more sonorous. Antimony is also often found in small quantity in bell-metal. Some of the finer kinds, used for small articles contain also a little silver, which much improves the sound.

When the tin is nearly one-third of the alloy, it is then most beautifully white, with a lustre almost like that of mercury, extremely hard, very close-grained, and perfectly brittle. In this state it takes a most beautiful polish, and is admirably fitted for the reflexion of light, for all optical purposes. It is then called *speculum metal*, which however, for the extreme perfection required in modern astronomical instruments, is better mixed with a very small proportion of other metals, particularly arsenic, brass, and silver. But, the basis of these compositions is copper, alloyed with nearly half its weight of tin. The use of this alloy for the same purpose, is of great antiquity, and certainly was in frequent use in the time of Pliny. Klaproth analyzed a portion of an ancient speculum, and found it to consist of 62 parts of copper, 32 of tin, and 8 of lead, which last was probably an adulteration of the tin, and not added designedly.

When more tin is added, the alloy loses its splendid whiteness, for which it is so valuable as a mirror, and becomes more of a blue-grey.

The speculum metal is, therefore, in the highest proportion of alloy of tin, that copper will admit for any useful purpose. An alloy, containing 6 of copper, 2 of tin, and 1 of arsenic, is nearly the proportion of Sir I. Newton's specula, which is very good, but polishes somewhat yellow. See Brass.

COPPERAS, a name given to green vitriol, or sulphat of iron. It is purified and prepared in the same manner as alum and saltpetre, being passed through several lixivia till it is wholly reduced to crystal. It is used in dyeing wool and hats black, in making ink, tanning leather, and in preparing a kind of Spanish brown, or colcothar, for painters.

A patent was granted in May, 1791, to Mr. William Murdock, of Redruth, Cornwall, for a method of making (from the same materials, and from processes entirely new) copperas, vitriol, and different sorts of dye, or dyeing stuff, paints, and colours.

The patentee directs any quantity of what remains after the calcination of mundic, or such other ores as contain sulphur, arsenic, and iron, to be washed in water; which is to be placed on the top, or on any other part of the kiln, house, or oven, while the mundic or other ores are burning; the heat of which will cause the water to evaporate; or the water may be evaporated to a crystallizing point, by exposing it to the heat of the sun; after which it should be suffered to stand for 24 hours, or longer, when crystals of copperas, or green vitriol, will be produced. From this process arises a considerable saving; as the ores remaining after fusion may be applied to various chemical purposes. See Iron.

CORN. See Agriculture.

COTTON is a soft, downy substance, found on the gossypium or cotton plant, which is of the shrubby kind; and when full grown, resembles the raspberry shrub.

There are different species of gossypium, all the natives of warmer climates. 1. The common herbaceous cotton, which creeps along the ground, has yellow flowers, succeeded by large oval pods, furnished with seeds and cotton. 2. The hairy American cotton, has hairy stalks, two or three feet high. 3. The Barbadoes shrubby cotton, has a shrubby stalk, branching four or five feet high. 4. The tree cotton, has an upright woody stalk, branching six or eight feet high. The flowers and pods of the three latter spe-

cies are like those of the first. The three species first enumerated are annual; but the fourth is perennial, both in stalk and root; and the common herbaceous cotton is the plant most generally cultivated.

The cotton shrub is propagated by the seed, which is sown in regular lines, about five feet asunder, at the latter end of September, or beginning of October; and at first but slightly covered, but after it springs up, and becomes a plant, the root is well moulded, and the ground hoed frequently. When the pods are come to maturity they burst open and disclose their seeds, intermixed with the flock or wool. When great part of the pods are thus expanded the crop begins. The wool is picked, and afterwards cleared from the seeds by a convenient machine, of very simple contrivance, called a gin, composed of two or three wooden rollers, ranged horizontally, close and parallel to each other, in a frame; at each extremity they are toothed, or channelled longitudinally, corresponding one with the other; and the central roller being moved with a treadle, makes the other two revolve in a contrary direction. The cotton is laid, in small quantities at a time, upon these rollers, whilst they are in motion, and readily passing between them, drops into a sack, placed underneath to receive it, leaving the seeds behind, which are too large to pass with it. The wool thus discharged from the seeds, comes afterwards to be handpicked, and cleansed thoroughly from any little particles of the pods, or other substances which may be adhering to it. It is then stowed in large bags, where it is well trod by a negro whilst it is thrown in, that it may lie close and compact; and the better to answer this purpose, some water is every now and then sprinkled upon the outside of the bag.

The finest sort of cotton comes from the island of Bourbon; then follow the growths of the Brazils, Berbice, Surrinam, Tobago, Carolina, Georgia, &c. that of Surat in the East Indies, is the most inferior kind.

The Cyprus cotton, on account of its whiteness, softness, and the length of its filaments, is accounted the best of the Levant cotton.

The season for sowing the cotton plant in the Southern States, is the month of April, or earlier. The ground for that purpose is prepared in the same manner as that of corn fields. Furrows being formed in the earth, the seeds are put into them in the same manner as French beans. The young plants come up with two yawning lobes, exactly like the cotyledonss of the common bean, and as soon as they appear above ground, the weakest are pulled up, and none left but those which are strong and vigorous. In the months of June and July, great care is taken to hoe the earth gently around them, and the crop is collected in the months of October and November. As some little time is requisite before the seed can be freed from its cover or husk, the first exportation does not take place till February or March, the year following. See SPINNING. See also BLEACHING.

CREAM, the most oily part of milk: it is specifically lighter than the other constituent parts, collects and floats on the surface, whence it is generally skimmed, in order to separate effectually the caseous and serous parts employed for the making of BUTTER and CHEESE, to which we refer.

Cream is an agreeable and very nourishing article of food, when fresh; but too fat and difficult to be digested by persons of a sedentary life, or possessed of a weak stomach. It is nevertheless of considerable service in medicine, as a lenient (though palliative) application to tetters and erysipelas, which are attended with pain, and proceed from acrid humours.

A Method of Preserving Cream.—Take 12 ounces of white sugar, and dissolve them in the smallest possible quantity of water, over a moderate fire. After the solution has taken place, the sugar ought to be boiled for about two minutes in an earthen vessel; when 12 ounces of new cream should be immediately added, and the whole uniformly mixed, while hot. Let it then gradually cool, and pour it into a bottle, which must be carefully corked. If kept in a cool place, and not exposed to the air, it may be preserved in a sweet state for several weeks, and even months.

CRUCIBLE. See POTTERY.

CUTLERY. As the cutler's art can only be acquired by practice, a minute theoretical treatise on this subject, becomes unnecessary. But as the tempering and setting of edge tool instruments constitutes the great desideratum of the art, (which however are seldom attended to, farther than appearance favours the disposal of the article,) we shall for the information of those who are desirous of directions, insert an abridgement of an excellent paper, by Mr. Nicholson, who received his information from Mr. Stoddart, a celebrated workman of the Strand, London.

"Cut steel is used for all works which do not require welding, and particularly for

fine cutlery. Huntsman's steel is used, but it is inferior to that formerly sold under that name. The best rule is to harden as little as possible above the state intended to be produced by tempering. Work overheated, has a crumbly edge, and will not afford the wire, hereafter to be described. The proper heat is a cherry red, visible by day light. No advantage is obtained from the use of salt in the water; or cooling that fluid, or from using mercury instead of water; but it may be remarked that questions respecting the fluid, are, properly speaking, applicable only to files, gravers, and such tools as are intended to be left at the extreme of hardness. Yet, though, Mr. Stoddart, did not seem to attach much value to peculiarities, in the process of hardening, he mentioned it as the observation and practice of one of his workmen, that the charcoal fire should be made up with *shavings of leather*: and upon being asked what good he supposed the leather could do, this workman replied, that he could take upon himself to say, that he never had a razor crack in the hardening since he had used this method, though it was a very common accident before.

To heat thicker parts before the slighter are burned away, plunge the piece into pure lead, containing little or no tin, ignited to a moderate redness, for a few seconds, that is to say, until when brought near the surface, that part does not appear less luminous than the rest. The piece is then stirred about in the bath, suddenly drawn out, and plunged into a large mass of water. In this manner a plate of steel may be hardened, so as to be perfectly brittle, and yet continue so sound, as to ring like a bell.

The letting down, or tempering of hard steel, is considered as absolutely necessary for the production of a fine and durable edge. It has been usual to do this by heating the hardened steel, till its bright surface exhibits some known colour by oxidation. The first is a very faint straw colour, becoming deeper and deeper, by increase of heat, to a fine deep golden yellow, which changes irregularly to purple, then to an uniform blue, succeeded by white, and several faint repetitions of these series. It is well known, that the hardest state of tempered instruments, is indicated by this straw colour, that a deeper colour is required for leather cutters' knives, and other tools that require the edge to be turned on one side; that the blue which indicates a good temper for springs, is almost too soft for any cutting instrument except saws, and such tools as are sharpened with a file, and that the lower states of hardness, are not at all adapted to this use. But it is of considerable importance, that the letting down or tempering, as well as hardening, should be effected by heat equally applied, and that the temperature, especially at the lower heats, where greater hardness is to be left, should be more precisely ascertained, than can be done, by the different states of oxidation. Mr. Hartley first practised the method of immersing hard steel in heated oil, or, the fusible compound of lead five parts, tin three, and bismuth eight; oil is preferable to the fusible mixture for several reasons. Mr. Nicholson gives an account of the temperatures at which the colours make their appearance upon hardened steel, while floating in the fusible mixture.

The cutting instrument being forged, hardened, and let down or tempered, it is ground upon a grindstone, of a fine close grit, called a Bilson grindstone, and sold at the tool shops of London at a moderate price. The cutlers use water; the face of the work is rendered finer by subsequent grinding upon mahogany cylinders, with emery of different fineness, or upon cylinders faced with hard pewter, called laps, which are preferable to those with a wooden face. The last polish is given upon a cylinder, faced with buff leather, to which crocus, or the red oxide of iron is applied with water. This last operation is attended with considerable danger of heating the work, and almost instantly reducing its temper along the thin edge, which at the same time acquires the colours of oxidation.

The setting now remains to be performed, which is a work of much delicacy and skill; the tool is first whetted upon a hone with oil, by rubbing it backwards and forwards. In all the processes of grinding or wearing down the edge, but more especially in the setting, the artist appears to prefer that stroke which leads the edge according to the action of cutting, instead of making the back run first along the stone. This proceeding is very judicious; for if there be any lump or particle of stone, or other substance lying upon the face of the grinder, and the back of the tool be first run over it, it will proceed beneath the edge, and lift it up, at the same time producing a notch. But on the other hand, if the edge be made to move foremost, and meet such a particle, it will slide beneath it, and suffer no injury. Another condition in whetting is, that the hand should not bear heavy; because it is evident, that the same stone, must produce a more uniform edge if the steel be worn away by many, than by

few strokes. It is also of essential importance, that the hone itself should be of a fine texture, or that its siliceous particles should be very minute. Mr. Stoddart informs me, that there are no certain criteria by which an excellent hone can be distinguished, from one of ordinary value, excepting those derived from the actual use of both: that the Turkey stone cuts fast, but is never found with a very fine grit: that the yellow hone is most generally useful, and that any stone of this kind requires to be soaked in oil, and kept wet with that fluid, or otherwise its effect will be the same as that of a coarser stone under the better treatment: and lastly, *that there is a green hone found in the old pavement of the streets of London, which is the best material yet known for finishing a fine edge.*

The grindstone leaves a ragged edge, which it is the first effect of whetting to reduce so thin, that it may be bended backwards and forwards. This flexible part is called the wire, and if the whetting were to be continued too long, it would break off in pieces without regularity, leaving a finer, though, still very imperfect edge, and tending to produce accidents, while laying on the face of the stone. The wire is taken off by raising the face of the knife, to an angle of about 50 degrees, with the surface of the stone. These strokes produce an edge, the faces of which are inclined to each other, in an angle of about 100 degrees, and to which the wire is so slightly adherent, that it may often be taken away entire, and is easily removed, by lightly drawing the edge along the finger nail. The edge thus cleared, is generally very even; but it is too thick, and must again be reduced by whetting. A fine wire is by this means produced, which will require to be again taken off, if for want of judgment, or of delicacy of hand, the artist should have carried it too far. But we will suppose the obtuse edge to be very even, and the second wire to be scarcely perceptible. In this case the last edge will be very acute, but neither so even nor so strong, as to be durably useful.

The finish is given by two or more alternate light strokes, with the edge slanting foremost, and the blade of the knife raised, so that its plane forms an angle of about 28 degrees with the face of the stone. This is the angle which by careful observation and measurement, I find Mr. Stoddart habitually uses for the finest surgeons' instruments, and which he considers as the best for razors, and other keen cutting tools. The angle of the edge, is therefore about 56 degrees.

The excellence and uniformity of a fine edge may be ascertained, by its mode of operation when lightly drawn along the surface of the skin, or leather, or any organized soft substance. Lancets are tried by suffering the point to drop gently through a piece of thin soft leather. If the edge be exquisite, it will not only pass with facility, but there will not be the least noise produced, any more, than if it had dropped in water. This kind of edge cannot be produced, but by performing the last two or more strokes on the green hone.

The operation of strapping is similar to that of grinding or whetting, and is performed by means of the angular particles of fine crocus, or other material, bedded in the face of the strap. It requires less skill than the operation of setting, and is very apt, from the elasticity of the strap, to enlarge the angle of the edge, or round it too much."

CYDER, or CIDER, a sharp, cool, and vinous beverage, made by fermenting the juice of apples. Some connoisseurs in this liquor are of opinion, that the juice of the more delicate table-fruit is generally more cordial and pleasant than that of the wild or harsh kinds; though others assert the latter to be in many respects preferable.

The apples should remain on the tree till they are thoroughly ripe, when they ought to be gathered with the hand in dry weather, that they may be protected both from bruises and from moisture. They are then to be sorted, according to their various degrees of maturity, and laid in separate heaps, in order to *sweat*; in consequence of which they greatly improve. This practice, however, appears to be useful only for such fruit as is not perfectly ripe, though some recommend it as being proper for *all* apples. The duration of the time of sweating may be determined by the flavour of the fruit, as different kinds require various lengths of time; namely, from eight or ten days to six weeks. The harsher and more crude the apples are, the longer it is necessary that they should remain in a sweating state, and not only be well dried, but the rotten parts carefully pared, before they are exposed.

The utility of the sweating practice is acknowledged in all the cyder countries, though various methods have been adopted in following it; as the apples are piled either in the open air, or under cover in houses. In the South-hams, a middle way has been adopted, to avoid the fermentation occasioned by piling them up in rooms, and which we recommend as the

best and most rational. Heaps of fruit are raised in an open part of the orchard, where by means ot a free air and less heat, the desired maturity is gradually effected with an inconsiderable waste of the juice and decay of the fruit, which thus becomes almost totally divested of rancidity. And though a few apples will rot even in this manner, they are still fit for use: all of them continue plump and full of juice, and heighten in a considerable degree the colour of the liquor, without imparting to it any disagreeable smell or taste.

The fruit is then to be ground till the rind and kernels are well bruised; a process which will considerably improve the flavour and strength of the liquor: when it should be allowed to stand for a day or two, in a large open vessel. It is next pressed between several hair-cloths, and the liquor received in a vat, whence it is removed into casks, which ought to be placed in a cool situation, or in the free air, with their bung-holes open. These casks are to be sedulously watched, till the cyder *drops fine*, when it is to be immediately *racked off* from the lees into other vessels. The first *racking* is a most important operation; as cyder, which is suffered to become foul again, by missing the first opportunity of racking it when fine, will never become what is called a *prime* liquor. After the clear part has been racked off, a quantity of lees or dregs remains, which, when filtered through coarse linen bags, yields a bright strong, but extremely flat liquid: if this be added to the former portion, it will greatly contribute to prevent fermentation, an excess of which will make the cyder thin and acid. To avoid such an accident, the casks should neither be entirely filled, nor stopped down too close; and, if the whole incline to ferment, it ought again to be racked. This latter operation, however, should on no account be repeated, unless from absolute necessity; as every *racking* diminishes its strength.

When there are no signs of any farther fermentation, the casks should be filled up with cyder of the best quality, and the bung-hole firmly closed with resin.

Some farmers, however, instead of racking, *fine* it with isinglass, steeped in white-wine, dissolved over the fire, and then boiled in a quantity of the liquor intended to be fined: in this state, it is added to that in the cask. Others, instead of dissolving the isinglass over the fire, digest it in white wine for the space of four or five weeks, during which time it acquires the consistency of a jelly; a quantity of this being beaten up with some of the liquor, the whole is worked into a froth, and mingled with the rest. As soon as the cyder becomes clear, it is drawn, or bottled off, as occasion may require.

Those who are anxious to prepare good cyder, ought diligently to watch every change of the weather, however slight; as the least neglect, at such times, is often detrimental to many hogsheads. In summer, the danger is much greater than in winter. There is, however, scarcely any distemper incident to this liquor, which may not, by a timely application, be easily remedied. If it become somewhat tart, about half a peck of good wheat, boiled and hulled in a manner similar to rice, may be put into each hogshead, which will effectually restore it; and also contribute to preserve it, when drawn out of one cask into another. Such a remedy is doubtless far preferable to that odious custom practised by too many cyder merchants, who put animal substances into their liquors, namely, veal, pork, beef, mutton, and even horse-flesh, for the purpose of fining them. This singular expedient, though sanctioned by the usage of our ancestors, we think it our duty to reprobate; because it is fraught with mischievous effects on the constitution of those, who are doomed to drink the cyder thus adulterated. By allowing a small quantity to stand, in an open vessel, for two or three days in a warm room, the fetid exhalation of the liquor will easily discover its ingredients.

Many estates where the soil is not proper for corn, might be greatly improved in value, by cultivating the different sorts of apples that are used in making cyder, which finds at all times a ready market, and requires no fuel in brewing it; besides that the labour occurs only once every year. The greater the quantities of cyder made together, the better it usually succeeds; but it will be necessary that the vessels in which the liquor is to be kept, be capacious and well seasoned. In this case, it will not only remain sound for a great number of years, but also progressively improve.

An ingenious *Treatise on Cyder*, in 4to. was published in the year 1804, in which the reader will find several pertinent instructions relative to this subject.

Apples thrive well in all the states of United America, except in the low lands of the maratime parts of Carolina and Georgia. In such a variety of soils and climates, apples of great diversity of taste and flavour must necessarily grow.

The cyder made from these apples accordingly differs very much; but in a general way it may be safely asserted, that the cyder of the United States equals that of any part of the world.

There have been numerous recipes published to make cyder, some of which have occasioned considerable losses. A few general and important rules will be given, for insuring good cyder, and afterwards some particular directions founded on experience.

1. The first and indispensible requisite for making good cyder, is to to choose perfectly ripe and sound fruit. Farmers, in general, are very inattentive to these points, but it is utterly impossible to make good cyder unless they be attended to.

2. The apples ought to be hand picked, or caught in a sheet, when the tree is shook. When they fall on the ground they become bruised, and as it frequently happens that they remain for some hours before pressing, the apples are apt to communicate a bad taste to the liquor from the bruised part.

3. After having sweated, and before being ground, the apples should be wiped, in order to remove a clammy moisture which covers them, and which, if permitted to remain, would impoverish the cyder.

4. The practice above noted to press the pumice in hair cloths is certainly much preferable to the common American custom of inclosing it in bands of straw, because the straw, when heated in the mow or stack, gives the cyder a bad taste.

5. After cyder has run from the press, it has been directed to strain it through hair sieves into a large open vat, which will contain a whole making, or as much as can be pressed in one day. When the cyder has remained in this vat a day, or sometimes less, according to the ripeness of the fruit of which it has been made, and the state of the weather, the pumice, or grosser parts of the pulp, will rise to the top, and in a few hours, or after a day or two at furthest, will grow very thick, and when little white bubbles break through it, draw it off through a cock or faucet hole, within three inches from the bottom, that the lees may quietly remain behind. This operation is of great importance, as the sinking of the feculent matter would greatly injure the liquor.

6. On drawing off the cyder from the vat, it must be tunned into clean casks, and closely watched, to prevent the fermentation; when therefore white bubbles, as mentioned above, are perceived at the bung hole, rack it again; immediately after which it will probably not ferment until March, when it must be racked off as before, and if possible in clear weather.

7. It is of great consequence to prevent the escape of the *carbonic acid*, or fixed air, from cyder, as on this principle all its briskness depends. To effect this, various expedients have been contrived. In the state of Connecticut, where much cyder is made, it is a common practice to pour a tumbler of *olive* oil into the bung-hole of every cask. Upon the same principle we have lately heard of a man, who boasted that he had drank brisk beer out of the same cask for *five* years, and that his secret was to cover the surface of the liquor with olive oil. Dr. Darwin also says he was told by a gentleman who made a considerable quantity of cyder on his estate, that he procured vessels of stronger construction than usual, and that he directed the apple juice, as soon as it had settled, to be bunged up close; and that though he had had one vessel or two occasionally burst by the expansion of the fermenting liquor, yet that this rarely occurred, and that his cyder never failed to be of the most excellent quality, and was sold at a great price.

To prevent a succeeding fermentation, put in a handful of powdered clay, and to preserve it, add one quart of apple brandy to each barrel: every cask must be filled up, and closely bunged.

8. When care has been taken to prevent the precipitation of the feculent matter which rises in the cyder, good liquor will generally fine without artificial means; but sometimes it is necessary to fine after the last racking, when the above mentioned article has been found to answer very effectually if used in the following way. For a barrel: cut one ounce of isinglass fine, put it into a pint of water, stir it frequently, and make a thick jelly. Dilute this with cyder, strain and mix it well with the liquor in the cask, by means of a long clean stick.

An ounce of *orris root*, in powder, gives a pleasant flavour to cyder.

A friend directs cyder to be bottled in July, to fill the bottles within two inches of the top, letting them stand twelve hours open before corking. Use strong porter bottles, and the best velvet corks. The bottling should be done in clear weather.

The following communication on the making and fining of cyder, is from the pen of Joseph Cooper, Esquire, of New Jersey.

"Cyder is an article of domestic manu-

facture, which is, in my opinion, worse managed than any in our country: perhaps the better way to correct errors, is to point out some of the principal ones, and then to recommend better plans.

"Apples are commonly collected when wet, and thrown in a heap, exposed to sun and rain; until a sourness pervades the whole mass, then ground, and for want of a trough or other vessels sufficient to hold a cheese at a time, the pumice is put on the press as fast as ground; and a large cheese is made, which requires so much time to finish and press off, that a fermentation comes on in the cheese before all the juice is out; and certain it is, that a small quantity of the juice pressed out after fermentation comes on, will spoil the product of a whole cheese, if mixed therewith. When either of the above errors will spoil cyder, we need not wonder at the effect of a combination of the whole, as frequently happens. As I have very often exported cyder to the West Indies, and to Europe, and also sold it to others for the same purpose, without even hearing of any spoiling; and as it is, my wish to make the productions of our country as useful as possible, I will give an account of my method of making this valuable liquor.

"I gather the apples when dry, put them on a floor under cover, and have a trough large enough to hold a cheese at once; and when the weather is warm, I grind them late in the evening, spreading the pumice over the trough to air it, as the cyder will thereby be enriched, and a fine amber colour in it produced: and here it may be remarked, that the *longer a cheese lies after being ground, before pressing, the better for the cyder, provided it escapes fermentation* until the pressing is completed. The following experiment will render this evident. Bruise a tart apple on one side, and let it lie until brown; then taste the juice of each part, and it will be found, that the juice of the bruised part is sweet and rich: so if sweet and tart apples are ground together, and put immediately on the press, the liquor which they produce will have the taste of both kinds of fruit; but if permitted to lie until the pumice become brown, the cyder will be greatly improved.

"I take great care to put cyder in clean sweet casks, and the only way to effect this, is to rinse or scald them well, as soon as the cyder is out, and not to permit them to stand with the lees, which will certainly cause them to become sour, or musty, or to smell. When my casks are filled, I place them in the shade, exposed to the northern air; and when fermentation takes place, I fill them up once or more, to cause as much of the feculent matter as possible, to discharge from the bung; when a clear white froth comes out, I put in the bung loosely, or bore a hole in it, and put in a spill, thereby checking the fermentation gradually. After this has subsided, I take the first opportunity of clear, cool weather, and rack it off into clean casks; which I prepare thus. When I draw cyder out of a cask in which it has fermented, I rinse it with cold water, and put in two or three quarts of fine gravel, and three or four gallons of water; the cask is well shaken, or rolled, to scour off the sediment always adhering to the cask, and which, if not removed, will act as a ferment to the liquor when returned to the cask, and spoil, or greatly injure the liquor.

After scouring the casks, I again rinse them; and I find advantage from burning a match of sulphur suspended in the cask by a wire, after putting in two or three buckets of cyder. A convenient way to perform this process, is to have a long tapering bung, so as that between the two ends, it will fit any hole; to the small end of this bung, drive in a wire with a hooked end, to hold the match. If the cyder stands a week, or more, after racking, previously to being put away in the cellar, I rack it again, rinsing the casks, but not with gravel, and remove them to the cellar. The late made cyder, I put in the cellar immediately after, or before the first racking, according as the weather may happen to be. The cyder intended to be kept till summer, I rack in cool, clear weather, in the latter end of February, or beginning of March; the casks must be kept full, and bunged as tight as possible."

Mr. Cooper fines with the isinglass jelly, mentioned above, but in case the liquor should not fine in ten days, he directs to rack it again, and repeat the fining as before; but says, it is best to rack it, whether fine or not, in ten or twelve days, lest the sediment should rise, which often happens. Mr. Cooper adds, "The foregoing operation should be performed previously to the apples being in bloom, but I have succeeded best in the winter, during steady cool weather. I have likewise had good success in fining cyder, directly from the press; when this is done, I set the casks with one head up, but covered; put in taps, and let them remain in a cool place, properly fixed for drawing. When the fermentation ceases, and the scum be-

gins to crack, I take it off carefully with a skimmer, and draw it from the sediment. If not sufficiently fine before the middle of winter, I fine it again as above.

"The settlings of my improved cyder spirit, (see article Brandy) in the proportion of two or three gallons to a hogshead of cyder, answers as well for fining as the isinglass jelly."

Cyder is a cooling, pleasant, and wholesome liquor, during the heat of summer, if it has been prepared without foreign ingredients, and properly fermented. On the contrary, when it is too new, or tart, or has, perhaps, been kept in leaden vessels; or the apples and pears have, after grinding them, passed through leaden tubes, we can by no means, recommend it as a salubrious beverage; because, that poisonous metal is easily dissolved by the acid, and thus gradually introduced into the body. However agreeably such cyder, or perry, may stimulate the palate, it cannot fail, sooner or later, to produce painful and dangerous colics, as it not unfrequently generates the most desperate and incurable obstipations, among those who accustom themselves to the free use of these liquors.

Cyderkin, Purré, or Perkin, is a liquor made of the *murk*, or lees, remaining after the cyder is pressed: these are put into a large vat, with half the quantity of cold water, which has been previously boiled: if that proportion be exceeded, the cyderkin will be *small*. The whole is left to digest for 48 hours, when it should be well expresed: the liquor thus obtained, is to be immediately barrelled, and closely stopped; it will be fit for use in a few days.

Cyderkin easily clarifies, and is used in many families, instead of small beer: if boiled after pressure, with a proper quantity of hops, it may be kept for any length of time.

Cyder-Spirit, an ardent liquor, drawn from cyder by distillation, in the same manner as brandy is from wine. The flavour peculiar to this spirit is by no means agreeable; but it may, with care, be totally divested of it, (see Charcoal) and become an excellent substitute for those deleterious preparations, sold under the name of spirituous compounds and cordials. Wholesale-dealers have lately availed themselves of this liquor; and, after imparting to it various flavours, they vend it as a substitute for others, but especially by mixing large quantities of it with foreign brandy, rum, and arrack, without the remotest apprehension of such fraud being detected. See Brandy.

Cyder Wine, is a liquor made by boiling the fresh juice of apples: after being kept three or four years, it is said to acquire the flavour and colour of Rhenish wine. The method of preparing it, consists in evaporating the juice in a brewing-copper, till one half be dissipated; the remainder is then immediately conveyed to a wooden cooler, whence it is barrelled, with the addition of a due proportion of yeast, and fermented in the usual manner.

This American process, has, of late years, been imitated in the cyder-countries, and particularly in the West of England, where several hundred hogsheads of cyder-wine, are annually prepared; and being supposed to contain no particles of copper from the vessels in which it is boiled, the country people consider it as perfectly wholesome, and accordingly drink it without apprehension. In order to ascertain the truth, various experiments were instituted by the late Dr. Fothergill; from the result of which he proved, that cyder-wine *does* contain a minute portion of copper; which, though not very considerable, is sufficient to caution the public against a liquor, that "comes in so very questionable a shape."

Independently, however, of the danger arising from any metallic impregnation, we doubt whether the process of preparing boiled wines be useful, or reconcileable to economy. The evaporation of the apple-juice, by long boiling, not only occasions an unnecessary consumption of fuel, but also volatilizes the most essential particles, without which the liquor cannot undergo a complete fermentation, so that there can be no perfect wine. Hence, this liquor is, like all other *boiled* wines, crude, heavy, and flat: it generally causes indigestion, flatulency, and diarrhœa. Those amateurs, however, who are determined to prepare it, ought at least to banish all brass and copper vessels, from this, as well as from every other culinary process.

D.

DAIRY-HOUSE, in rural economy, a place appropriated to the management of milk, butter, cheese, &c. See MILK, BUTTER, CHEESE, CHURN.

A dairy ought to be so situated, that the windows, or the lattices, may never front the south, south-east, or south-west; and it should at all times be kept in the neatest order. Lattices are also preferable to glazed lights, as they admit a free circulation of the air. It has, however, been objected, that the former affords access to the cold air of winter, and to the sun in summer; but either may be easily remedied, by making the frame somewhat larger than the lattice, and constructing it so as to slide backward and forward at pleasure. Across this frame, pack-thread may be stretched, and oiled paper pasted on it, which will thus admit the light, and effectually keep out the sun and wind.

During the summer, dairy-houses cannot be kept too cool: they ought therefore to be erected, if possible, near a cold spring, or running water; and where it is practicable, to conduct a small stream through the premises, it will much contribute to the convenience and utility of the place. Dr. Anderson observes, in his practical essay on the management of the dairy, (published in the 3d and 4th vols. of his ingenious "*Recreations in Agriculture*," &c.) that if the water can be introduced by means of a pipe, so as to fall from some height on the floor, it will be productive of many advantages, particularly by preserving a continual freshness, and purity of the air. Dairy-houses should therefore be neatly paved, either with red brick, or smooth hard stone, and laid with a proper descent, so that no water may stagnate. This pavement should be well washed every day, during the summer; and all the utensils, here employed, be kept with unremitting attention to cleanliness. Nor should the churns be at any time scalded in the dairy; as the steam arising from hot water tends greatly to injure the milk. For similar reasons, neither the cheese and rennet, nor the cheese press, must be suffered to taint the atmosphere; as the whey and curd will diffuse their acidity over the whole building.

All the utensils of the dairy should be made of wood, in preference to either lead, copper, or cast iron; for these metals are easily soluble in acids; the solutions of the two first are in a high degree poisonous; and, though the latter is in itself harmless, the taste of it renders the productions of the dairy very disagreeable. The cream-dishes, when perfectly clean and cool, ought to be filled with the milk, as soon as it is drawn from the cow, and has been carefully strained through a cloth, or cloth-sieve, made of hair or silver-wire; the latter of which, as Dr. Anderson justly remarks, is more wholesome than those of other metals. These dishes should never exceed three inches in depth, but may be so wide as to contain a gallon, or a gallon and a half of milk; when filled, they ought to be placed on shelves, to remain there till the cream be completely separated. Now it is to be taken off with nicety, by a skimming-dish, (without lifting or removing the milk, or shedding any of it on the floor, which would soon corrupt the air of the room,) and then deposited in a separate vessel, till a proper quantity be collected for churning. A firm, neat wooden barrel, which is open at one end, and has a lid closely fitted to it, appears to be well calculated for this purpose; a cock, or spigot, ought also to be fixed near the bottom, to draw off the thin, or serous part, that may drain from the cream; and the inner side of the opening should be covered with a piece of fine silver wire-gause, in order to prevent the latter from escaping, while the former is allowed to pass.

But, if notwithstanding the fatal consequences, arising from the use of metallic utensils, or of earthen vessels glazed with lead, farmers still persist in employing them, it ought to be a constant and indis-

pensible rule, to scald and scour them properly, with salt and water, every day, and to dry them thoroughly, before the milk is deposited in them. Lastly, it is sincerely to be wished, that all the utensils employed in the dairy, of whatever materials they may consist, should be cleaned with similar care, previously to their being used; and, as long as the least acid smell is perceptible, they ought to undergo repeated scourings, till they are completely sweetened.

DIGESTER. The digester is an instrument invented by Mr Papin about the beginning of the last century, and usually called Papin's digester. It is a strong vessel of copper or iron, with a cover adapted to screw on with pieces of felt or paper interposed. In some vessels of this kind the cover is made of an elliptical form, and is inserted through an opening of the same figure, which it completely closes by application of its upper surface, to the internal surface of the vessel. A valve, with a small aperture, is made in the cover, the stopper of which valve may be more or less loaded either by actual weights, or by pressure from an apparatus, on the principle of the steel-yard. Instead of the common valve sir A. N. Edelcrantz employs a cylinder in the cover, with a steam-tight piston. This piston may be loaded with any weight, and the cylinder is perforated with small holes, at different heights, and a larger hole near the top, to allow an exit to the steam receding to the pressure it exerts.

The purpose of this vessel is to prevent the loss of heat by evaporation. The solvent power of water, when heated in this vessel, is greatly increased, chiefly, no doubt, on account of its increased temperature, and likewise in all probability on account of the pressure exerted by the reaction of the elastic water or steam, which is upon the point of being generated

We do not hear of many experiments made by this engine. The inventor proposed it as a culinary utensil, by which the grisly and bony parts of animals might be combined with water, in the form of a jelly, as is in fact the case. But whether a food, so loaded with the phosphoric salt of lime, would be wholesome, may perhaps admit of serious doubts: it is likewise very liable to acquire an empyreuma, if the heat be carried a little too high.

Bergmann thought that the digester might exhibit a considerable solvent power of water upon the pure earths, and he considered the deposition of siliceous earth from the hot water, of the stupendous fountain, of Geyser, in Iceland, mentioned by Von Troil, and others, as a proof of such a solution.

Cast iron digesters have recently been manufactured in England, and successfully applied to culinary purposes. They have also been found incomparably more economical than the various kinds of stew-pans formerly employed.

DISTILLING or DISTILLATION. Is the process of evaporation performed in vessels adapted to condense or collect the substance evaporated

Distillation in the large way is usually carried on in an apparatus composed of three parts, namely, the alembic or boiler in which the substance is heated, the head or capital, a dome-shaped continuation of the former, in which the vapours are collected, and a tube or worm spirally disposed and passing through a tub of water, in which the distilled vapour is condensed into a liquid. For smaller purposes this apparatus is often simplified, and the capital is enclosed in a case which holds cold water, whereby the condensation takes place in the capital itself.

Another apparatus more usual in experiments is a retort, generally of glass, which answers the purpose both of boiler and capital, and a globe-shaped receiver fitting to the retort in which the condensation is completed. The greatest improvement perhaps ever made to chemical apparatus is the (comparatively) modern addition of a separate series of tubes and vessels to convey and collect the gaseous products, and to avoid all the danger from sudden expansion without incurring the necessity (formerly required) of letting off to waste a large portion of the difficultly condensible, but often most important, products of the operation.

The practical uses of distillation are too numerous to be mentioned. By it the volatile part of any substance is separated from that which is fixed, as in the distillation of turpentine, in which the essential oil rises and the resin is left behind: the more evaporable is separated from the less evaporable, as in the preparation or rectification of ardent spirit; liquids are freed from foreign or accidental impurities, as in the distillation of common water: volatile substances are united in an easy and commodious manner, as in preparing the odorous distilled waters of aromatic vegetables: bodies are decomposed and analysed, new compounds are formed, and a knowledge is gained of the native and chemical properties of natural substances.

When the products of distillation are

solid and dry, the process is usually termed *sublimation.*

With respect to the practical part of distilling or refining, we shall first observe, that *the heat should in all cases be as gentle and uniform as possible.* Accidents may be effectually prevented by employing a worm of a proper width, and by rectifying spirits in a *water-bath;* which, if sufficiently large, will perform the operation with all the despatch requisite for the most extensive business. The vessel in which the rectification is effected, ought to be immersed in another filled with water up to the neck, and loaded with lead at the bottom, in order to keep it firm and steady. The process will thus be managed as expeditiously as if the vessel were placed over an open fire, and without the apprehension of being disappointed; nor will it be necessary at any time to raise the water in the bath to a boiling heat.

To obtain spirit from fermented liquor is the business of the distiller; but to refine and purify it belongs to the rectifier. The second operation is so dependent on the first, that unless the distillation be carefully conducted, the rectification will be rendered both tedious and difficult.

The art of distilling malt spirit, may be reduced to the following principles. 1. To obtain spirit free from the oil of malt. 2. To raise the vapours in the most economical manner. 3. To condense them as speedily as possible; and 4. To prevent empyreuma.

The first may be done by mixing a small quantity of sulphuric acid with the wash; and the remaining three by a proper construction of the still, and the necessary care in distillation.

The still should be so constructed as to be capable of containing a column of fermentable matter, considerably broader than high, to prevent the liquor at the bottom from being burnt before the upper part is heated. The top should be as wide as the bottom, to give the vapours free and complete liberty to escape. By the common construction of the stills, they are incessantly returned into the boiler, especially at the commencement of the process.

Various contrivances have been adopted by the distillers to prevent the wash from burning in the still. Mr. Anderson's apparatus answers this purpose effectually.

Rectification is simple and easy, provided the previous operations have been well managed; but if an empyreuma has been contracted in the still, or the fœtid oil has been combined with the spirit, then it becomes more difficult. On the contrary, if these have been avoided, nothing more is necessary than to mix the spirit with an equal quantity of pure water, and recommit it to distillation, when it will come over pure.

When the liquor has been burnt in the still, it ought to be kept for some weeks, in *charred* vessels: a quantity of charcoal should be mixed with the spirit and water, previously to the distillation. This will, generally, be found a sufficient remedy for empyreuma, but will not correct the disagreeable flavour communicated from the admixture of the fœtid oil. Many substances have been used for this purpose, none of which, I think are fully adequate to the end proposed.

Filtration has been recommended, but the oil is so intimately mixed with the spirit, that a considerable quantity will pass through the filter. The operation is also tedious, and some of the spirit evaporates during the process. Alkaline salts are frequently mixed with the spirit, previously to rectification, such as the carbonat of pot ash, but more frequently the carbonat of soda. They, however, are both liable to considerable objections, when unassisted by any other substance; for, although they combine with the oil, and, in some degree, prevent its rising in vapours, yet they communicate an urinous flavour to the spirit, which is highly injurious. Neutral salts, *quick-lime*, calcined bones, and chalk, are equally liable to objection, as they do not effectually deprive the spirit of the oil which it holds in solution, and an improper flavour is also contracted from them.

Of the accidents that too often happen in performing the processes of distillation.

Among the accidents which frequently happen in distilling, the least of all is for the operation to miscarry, and the ingredients to be lost. And this being a subject of the greatest importance, we shall treat it with all possible accuracy.

All accidents are occasioned by fire, their primary cause; by want of attention they get too much heat, and fear often suffers them to become irremediable.

The first accident which may happen by the fire, is when a distiller, by too great a heat, causes the ingredients to be burnt at the bottom of the still; by this means his liquor is spoiled by an empyreumatic taste, and the tin is melted off from the alembic. An empyreuma resembles the smell of burnt tobacco, and is produced in liquors by too great a degree of heat. To illustrate this, distil any fruit, flowers, or aromatic whatever, but

especially something the smell of which is very volatile, draw off only the best, unlute the alembic, and what remains in the still will be found to have a very disagreeable smell; whence it follows, that if a little more had been drawn off, it would have spoiled what was before obtained.

If the fire be too violent, the extraordinary ebullition of the contents causes them to ascend into the head; and, if in a glass alembic, they fall ignited into the recipient; the heat breaks it, the spirits are dissipated, and often take fire from the heat of the furnace.

If the fire be too strong, the bottom of the still becomes red hot, the materials inflamed, and consequently the fire reaches the recipient.

When an earthen alembic is used, the closest attention is requisite, to keep the fire from burning the materials at the bottom—the head, which is always of glass, bursts, and the spirits are spilt, and often catch fire. And the remedy becomes the more difficult, as earth retains the fire much longer than a common alembic.

If the alembic be not firmly fixed, it is soon put out of order, falls down and unlutes itself; thus the liquor is spilt, and the vapour sets the spirits on fire.

If all the joints be not carefully luted, the spirits at their first effort issue through the least aperture, run into the fire, which is propagated into the alembic by the vapour.

In distillations where the phlegm ascends first, its humidity penetrates the lute, and loosens it, so that, when the spirituous vapours ascend, they are exposed to the same accident.

Lastly, when the recipient is unluted, especially if nearly full, without the greatest circumspection, the spirits will be spilt, and so catch fire.

Hitherto, we have only given a simple account of what daily happens to distillers; but the consequenceses of these accidents are infinitely more terrible than the accidents themselves; for an artist to lose his time, his labour, and goods, is no small matter; but it follows from what we have premised, that both his life and fortune are in danger from these conflagrations. Instances of the former are too common, as well as of the latter, relating to the danger to which the operator is exposed.

The spirits catch, the alembic and recipient fly, and the inflamed vapour becomes present death to all who breathe it.

The rectifiers who perform the most dangerous operations of distillery, are particularly exposed to these terrible accidents; the fineness of the spirit, at the same time that it renders it more inflammable, also causes the fire to spread with the greater rapidity. And, when their store houses are once on fire, they are seldom or never saved.

To prevent accidents, two things especially must be known, and adverted to.

1. The knowledge of the fire; which depends on the fuel, whether wood or coal.

2. The manner of luting, so as to prevent the vapours from escaping through it, and by that means of setting the whole on fire.

It is evident, that the larger the alembic, the more fire is necessary. What has not been digested, also requires more fire than that which has been prepared by that operation. Spices require a stronger fire than flowers; a distillation of simple waters, more than that of spirituous liquors.

The surest way of ascertaining the necessary degree of fire is, to regulate it by the materials, as they are more or less disposed to yield their spirits, &c. and this is done as follows. The operator must not leave the alembic, but attentively listen to what passes within, when the fire begins to heat it. When the ebullition becomes too vehement, the fire must be lessened, either by taking out some of the fuel, or covering it with ashes or sand.

It requires a long experience in the several cases, before a distiller can acquire a competent knowledge in this important point. Nor is it possible to determine the degree of fire from the quantity of fuel; judgment, assisted by experience, must supply this defect.

Every thing being determined with regard to the degree of fire, we shall now proceed to explain the method of luting alembics.

By the term luting an alembic, we mean, the closing the joints through which the spirits might transpire.

Lute is a composition of common ashes, well sifted, and soaked in water; clay, and a kind of paste, made of meal or starch, are also used for this purpose; which, as we have before observed, is to close all the joints, &c. in order to confine the spirits from transpiring. See Cement.

Good luting is one of the surest methods for preventing accidents. From an alembic, where all transpiration is prevented, nothing is to be feared, but from the too great fierceness of the fire; and that may be regulated by the rules already laid down.

The refrigerating alembic is mostly used. The body and the head are joined to each other; but notwithstanding the greatest care be taken in luting the juncture, there will still be some imperceptı-

ble interstice for transpiration; and the least being of the greatest consequence, a piece of strong paper should be pasted over the joint, and the alembic never left, till the spirits begin to flow into the receiver, in order to apply fresh paper, if the former should contract any moisture. The master himself, should carefully attend to this; and whatever precautions may have previously been used, the eye must be constantly upon it.

The alembic, when vinous spirits are distilled, should be luted with clay, carefully spread round the junctures, in order to prevent all transpiration; because the consequences here are terrible; for, when the fire catches a large quantity, it is oft en irremediable. Besides, as this earth cracks in drying, it must be often moistened, and fresh applied, on the first appearance of any occasion for it.

The retort is also luted with clay; but as glass retorts are also used, they are often coated with the same clay, to prevent their melting by the intenseness of the fire.

Lastly, the earthen and glass alembics are luted with paper and paste, as above. Having thus explained the great importance of circumspection with regard to luting, and the degree of fire, we shall now proceed to the third method of preventing them.

Of the remedies for accidents, *whenever they happen*—

The most essential, are courage and presence of mind; fear only increasing the misfortune.

1st. If the fire be too violent it must be covered, but not so as totally to prevent its action, as by that means the process of the distillation would be interrupted, and render it more difficult and less perfect.

2d. When the ingredients burn, which will soon be discovered by the smell, the fire must be immediately put out, in order to prevent the whole charge of the still from being entirely spoiled, which would otherwise inevitably be the consequence.

3d. If the spirits should catch fire, the first care is to unlute, immediately, the receiver, and stop both the end of the beak and the mouth of the receiver with wet cloths.

The fire must then be put out; and if the flame issued through the luting, the joints must be closed with a wet cloth, which, together with water, should never be wanting in a distil-house.

4th. If the alembic be of earth, and the contents burn at the bottom, the fire must be immediately put out, the alembic removed, and water thrown upon it, till the danger is over; and for farther security covered with a wet cloth.

5th. If after care in closing the junctures, to prevent transpiration, you perceive any thing amiss, while the spirits are ascending, apply clay, or any other composition, in order to stop the aperture, and have always a wet cloth ready to stifle the flame, if the spirits should take fire.

6th. If the heat detaches the lute, or it becomes moist, immediately apply another, having always ready what is necessary for performing it. Should the transpiration be so violent that you cannot immediately apply a fresh lute, clap a wet cloth round the joint and keep it on firm and tight, till the spirits have taken their course. But if, notwithstanding all your efforts, the transpiration should increase, so that you fear a conflagration, remove the receiver as soon as possible from the fire, and afterwards your alembic, if portable; but if otherwise, put out the fire immediately.

7th. The charge being worked off, be cautious in luting the receiver, that nothing be spilt on the furnace, and carry it to some distance from it, that the spirits exhaling may not take fire.

8th. Lastly observe, that whenever a remedy is required, there must be no candle used; for the spirituous vapours easily take fire, and propagate the flame to the vessels from whence they issue.

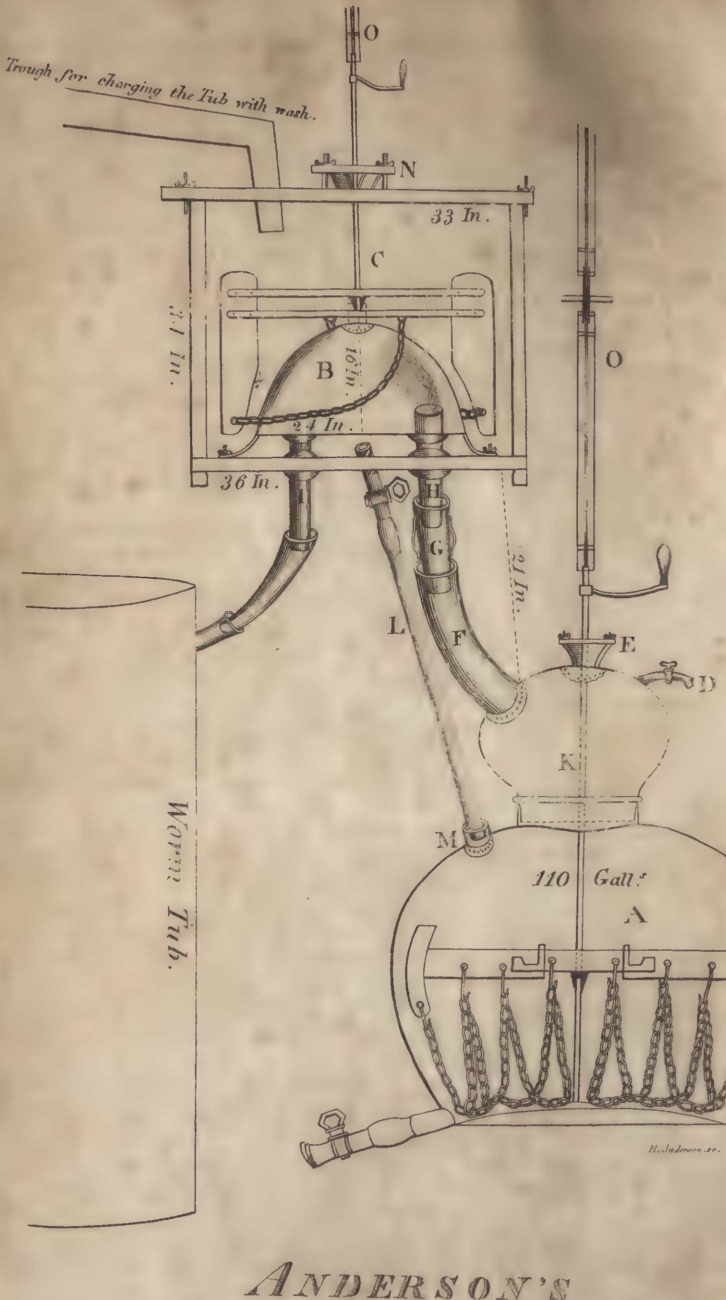
All that has been hitherto said, concerns only the management of the alembic; but what remains, is still more interesting, and relates to those who work it, that they may not, by conquering the accident, destroy themselves.

On discovering any of the above accidents, when the flame has not yet reached the spirits, let the remedies already mentioned be applied, either with regard to the lute, or the violence of the fire. But if the flame has reached the alembic, the following precautions are to be used.

The operator must not approach the alembic without a wet cloth over his mouth and nostrils, it being immediate death to inhale the inflamed vapour.

In hastening to stop any accident, be careful to approach on the side opposite to that whither the air impels the flame; for, without this precaution, you would be involved in it, and could not, without the utmost difficulty, extricate yourself from it.

If, notwithstanding this precaution, the eddy of the air should force the flame to your side, quit the place immediately, and do not return till its direction be changed, always taking care to have a wet linen cloth before your nose and mouth, and keep yourself on the side opposite to the direction of the flame: and also to have another such cloth, in order to smother



ANDERSON'S
Patent Condensing Tub.

the flame, and close the crevice, through which the spirits issue.

Should it be your misfortune to be covered with inflamed spirits, wrap yourself in a wet sheet, which should always be ready for that purpose. Self-preservation is of so great importance, that any of these precautions should not be omitted in such variety of dangers.

If the fire has acquired such a head that it cannot be stopt, the receiver must be broken, and the alembic, if portable, thrown down; but no person must be suffered to go near them, especially those who are strangers to the business.

In a desperate case, like that of a large quantity of rectified spirit taking fire, if time permit, the communication of the beak of the alembic, with the recipient, which is usually a cask, must be cut off, by closely stopping the bung; and be sure no candle come near the receiver, leaving the rest, as the danger would be too great to expose one's self to the flames of a large charge, and the distiller's safety should be principally considered.

A patent was granted in July, 1773, to Mr. Thomas Danforth, of Charlestown, in Massachusetts, for his invention of a method of condensing the vapour arising in distillation: as the term of his privilege is now expired, we insert the following particulars. The whole improvement consists in making the worm-vessel, or that containing the water to cool the worm, or vessel which receives the steam or vapour to be condensed, (whether the steam-vessel be a worm, strait tube, or of any other form), so that it may act in a manner similar to a syphon or crane; and, upon the same principles, by making it air-tight; excepting a communication by a tube, or part of the vessel itself, with the water that supplies it, and an aperture from a tube or part of the vessel, below the horizontal level of the surface, in the reservoir, where it first enters; in order that the water may escape in the same proportion of time and quantity, as it flows into the vessel in the reservoir.

Of the many patents for improvements in distilling, which have been granted to ingenious men within a few years, both in Europe and America, none have been more deservedly obtained than that by A. Anderson, Esq. formerly of Philadelphia, but at present residing at Lamberton, New-Jersey. Mr. Anderson's patent is taken out in general terms, "for making use of steam arising in distillation, for heating wash or any subject to be distilled, by means of a condensing tub, in which the wash is so placed as to receive the whole heat of the steam, the wash at the same time, condensing the steam." The process saves wood and labour, in the proportion of 3 to 1 of the common stills At the works of Messrs. Anderson and Hall, Lamberton, two stills are in operation, of 110 gallons each, each of which charged with 90 gallons, is run off *twelve times in 24 hours.*

Explanation of the annexed engraving of Anderson's Patent Condensing Tub.

A. Still to contain 110 gallons, exclusively of the head, as near this shape as possible.
B. Half globe made of copper 30lb. to the sheet, bottom of copper, a thimble on the centre of the top, 24 inches in the bottom, and 16 high.
C. Tub for holding the charge of wash, 36 inches wide in the bottom, 33 at top, and 34 deep, made of 1 ¼ cedar or white pine.
D. Small brass cock, to be opened when the charge is let into the still from the tub.
E. Stuffing box made of copper, to prevent the steam escaping by the spindle; the box stuffed with tow, and screwed down fast.
F. Pipe from the head of the still, 4½ inches wide.
G. Pipe: the lower end fitting into the pipe F, and receiving the pipe H, and large enough to slip up on the pipe H, so as to leave the head free to be taken off.
H. Pipe: the lower end fits into the pipe G, and passes through the bottom, 4 inches, to prevent the condensed steam returning into the still, and fastened firmly in the bottom of the half globe.
I. Pipe to convey off the condensed steam into the worm, fitted even in the bottom of the half globe; the other end fits into the mouth of the worm.
K. Iron spindle, with its handle to stir the still, with the cross piece and chains.
L. Charging pipe, 3 inches wide, with a large cock screwed into the bottom of the tub, and the lower end fitting into the pipe M, in the breast of the still.
N. Stuffing box made of wood.
O. Spindles when used by water.

DISTILLING APPARATUS. Besides those of Mr. Anderson's, already mentioned, it may be necessary to notice some others that are used for common, as well as for chemical, purposes.

A, *(Fig. 1, Plate I.)* represents a retort used for distillation. It is a vessel, either of glass or baked earth, for containing the liquid to be distilled. When

it has a small neck, a, with a stopple fitted to it, for introducing the materials through, it is called a *tubulated retort.* B is the receiver for condensing the vapour which is raised, and into which the neck of the retort is inserted. The joining, b, is made air-tight by means of a *lute.* Various methods are used for supporting both the retort and receiver, according to the degree of heat to be employed in the process, and several other circumstances.

When great heat is employed, earthen retorts are used, which are placed on or in the fire. When a less heat is wanted, glass retorts are generally employed, which must not be placed immediately on the fire, unless they are coated over with a composition of clay and sand, which is sometimes done. Glass retorts are generally placed in a sand-bath, or suspended over a lamp, for which Argand's lamp is the best. The receiver is placed upon some stand convenient for the purpose, with a ring made of hay under it, or some such contrivance, to keep it steady.

A, *(Fig. 2.)* is a vessel called a *mattrass*, for the same purpose, having a vessel, B, called an *alembic*, fitted to the head. The liquid raised by heat into the state of vapour, is condensed in the alembic, and falls into a groove all round its inside, from whence it runs out by the spout C, into the receiver D.

Fig 3, are conical tubes that fit into one another, for lengthening the necks of retorts, &c. to connect them with the receivers at any distance: they are called *adopters.*

Fig. 4, are phials with bent glass tubes fitted in them, for disengaging gases, and similar experiments: they were used by Priestley, and are hence called *Priestley's bottles*, and sometimes *proofs:* they are either tubulated or plain.

A, *(Fig. 5.)* represents a *common still.* It is a large vessel of copper, into which the materials to be distilled are put. The still is built up in brick-work, which covers it up to the neck; the fire is applied underneath, and runs round it in a spiral manner. B is the *head* of the still. This head is connected with the *worm,* which is a spiral tube, immersed in a vessel of cold water, called the *refrigeratory,* or *cooling tub,* C. The liquor being condensed in its passage through the worm, runs out at the cock D, into the vessel placed there to receive it.

This is the construction of the common still for distilling spirituous liquors; but a very great improvement has been made upon this instrument in Scotland within these few years. This improved apparatus is known by the name of the Scotch still, a section of which is represented by *Fig.* 6. The principle of the improvement consists in exposing a great quantity of the surface of the fluid to the action of the fire, and affording a more ready means for the escape of the vapour or gas.

A, is the body of the still, made very shallow and concave at the bottom, in order that the fire may act better upon it. bb, are a number of tubes opening into the still, and communicating with the neck of the still B, in order to convey the vapour off as soon as it is formed. cc, is a cover that shuts down over the pipes and top of the still, to keep it warm, by preventing the loss of heat which would be occasioned by the contact of the cold air. This is effected by the quantity of air that is confined between the cover and the top of the still; for it is a fact which is now well known, that *confined* air is a *non-conductor* of heat. In general, the heads of stills are kept warm by laying blankets upon them, at least when this is attended to, as it ought always to be; but this metallic covering, by surrounding the still with a quantity of confined air, answers the purpose still better.

DISTILLED SPIRITS. Under the articles Brandy and Alcohol, we have already given a description of the processes by which ardent spirit is made; we shall therefore in this place only mention a few circumstances in the preparation of *corn-spirits* and *rum.*

The greater part of the common spirituous liquors consumed in this and the countries of Europe where the vine does not grow, is prepared from fermented corn of one kind or other, mixed occasionally, when it suits the purpose of the distiller, with molasses, and sometimes with carrots and other sub-saccharine vegetables. But when there is no scarcity of grain, this is by far the greatest, and often the only ingredient.

The spirit thus procured is rectified for sale by being redistilled with juniper berries, turpentine, and many other substances, to give it the desired flavour and appearance.

The grain, if barley is used, is generally first malted in the usual manner, and in Scotland is dried with peat, the smoke of which gives that peculiar flavour which is found in *whisky,* the spirit distilled from it. It is then ground to coarse powder, mashed, and the infusion fermented with yeast in large tuns. In this state it is a strong ale, and only differs from the malt liquors used for drinking, in containing no hops nor any other bitter. This fermented liquor is called *wash,* and is then fit for the first distillation.

DISTILLING APPARATUS.

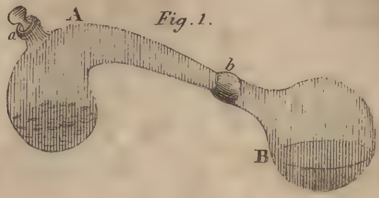


Fig. 1.

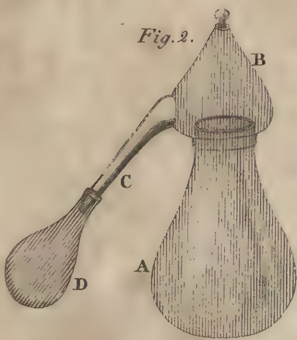


Fig. 2.


Fig. 3.


Fig. 4.

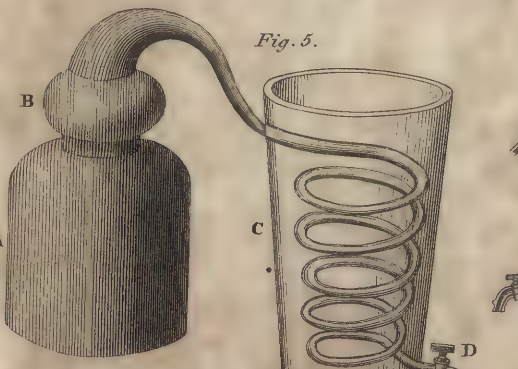


Fig. 5.

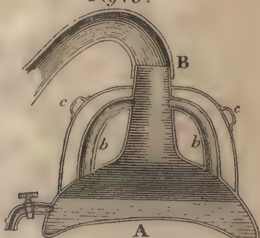


Fig. 6.

H. Anderson sc.

The theory and practice of distillation having been described, (see ALCOHOL,) we shall not here repeat it, except to mention, that several additions are made to the wash with a view either of increasing (as is supposed) the yield of spirit, or of correcting and keeping down the essential oil derived from the malt, which is apt to give it a nauseous flavour; or of regulating the boiling within the still, and preventing it from boiling over or *running foul;* or of neutralizing the acid generated during the fermentation, which remarkably lessens the product of spirit. For all these purposes soap is accounted the best addition, and large quantities of it are employed for this purpose in distilleries. Others use alkalies.

During the distillation the first spirit that comes over (as in the distillation of wine) is oily and turbid, and often of a nauseous flavour, owing to the oil of the malt which accompanies it in all these changes. The spirit then runs clear and continues so to the last, but constantly decreasing in strength, becoming more watery, and therefore of less specific gravity.

The whole of the spirit thus obtained is then again distilled or *rectified,* and in this process the middle runnings from the still are received apart from the first portion which is too oily and turbid, and from the latter which is too watery to come up to the established proof. It is in the rectification also that the additions which give a peculiar flavour to the spirit, (such as juniper berries, &c.) are made.

The general process of the distillery is simple, and certainly not difficult of management to ensure a certain degree of success, since it is carried on in the small way by hundreds of farmers and ignorant persons, in those remote parts of the island which offer the greatest facility of eluding the excise duties. But in conducting vast and expensive works a large share of practical skill is required, and almost every distiller professes to have some peculiar nicety of practice in the management of the process or the construction of the apparatus.

The form of the still in particular has undergone many successive alterations; and by gradually widening the bottom and contracting the height of the boiler, distillation is now carried on with a rapidity that would almost exceed belief were it not perfectly well authenticated. After successive improvements and a considerably complicated apparatus, a still has been constructed which contains only 40 gallons in the body and 3 in the head, in which the time of charging, boiling and running, and letting off the waste liquor, amounts only to *two minutes and three-quarters* when the charge of wash is 16 gallons, which is two-fifths of the whole contents. In rectification, which is a slower process, the charge is 24 gallons, and the time of distilling about ten minutes. This rate of working however is far beyond the ordinary rate.

It is not necessary to malt grain in order to make it ferment sufficiently to yield a good spirit, and not only barley but any other grain will answer the same purpose. In this country a mixture of barley and malt is generally preferred; in Holland the very finest geneva is made from wheat and malt, but more commonly from malt and rye, which latter yields more spirit than wheat. Very superior care and attention seems to be bestowed in conducting the whole process.

The greater number of distillers proceed in the following manner. A quantity of rye flour coarsely ground is mixed with a third or fourth part of malt and put into the fermenting tub with cold water, stirring it well with the hands to prevent the meal from clotting. Sufficient water is then added of a blood warmth, after which the ferment is mixed with the whole, which is composed of the yeast of former operations dried and kept for a certain time. If the weather is favourable and the heat well regulated, the fermentation begins in six hours, and terminates on the third day, and the liquor becomes transparent and assumes a hot pungent taste. The distillation is then proceeded upon immediately, before the liquor turns sour, which is avoided as much as possible. The distillation is conducted very slowly, that the spirit may be as little as possible impregnated with the oil of the grain, to which much of the unpleasant flavour of the ordinary spirits is justly attributed. The first spirit is then rectified by a second distillation over juniper-berries, or in *double Geneva* by a third process. In some of the ordinary sorts, however, the juniper-berries are mixed with the fermenting materials, and one distillation suffices. In the common geneva or gin vulgarly used in this country, the fine juniper flavour is coarsely imitated by turpentine.

Rum is prepared by distilling a fermented liquor made from molasses, and other refuse saccharine matter, which is procured during the manufacture of raw sugar in the West Indies. The common process in Jamaica is the following. The materials for the fermentation are, molasses or the treacle which drains from the sugar, scummings of the hot cane juice,

or sometimes raw cane liquor, lees or *dunder* as it is called, and water. The dunder answers the purpose of yeast, and is usually prepared by a separate fermentation of cane sweets and water. The materials being mixed in due proportions, (which are about equal parts of scummings, dunder, and water,) the fermentation begins very soon, and in 24 hours the liquor is fit for the first charge of molasses, which is added in the proportion of 3 gallons for every 100 gallons of the liquor. Another charge is added in a day or two afterwards. The heat in fermentation should not exceed 90° or 94°, so that in this climate it is necessary to keep the fermenting tubs as cool as possible. The fermentation falls in six or eight days, and the liquor grows fine and fit for distillation. In about two hours after lighting the fire the spirit begins to run (in a still of 1200 gallons) and it is collected as long as it remains inflammable.

The first spirit is called, in the country, *low wines*, and it is rectified in a smaller still to the Jamaica proof, which is that in which olive oil will sink. About 220 gallons of proof rum are obtained from 530 gallons of low wines. See FERMENTATION.

DISTILLED WATERS. Of this large class of chemical preparations, but almost entirely devoted to pharmacy, a few observations may be made.

The object of them all is to impregnate water, solely with the aromatic or flavouring principles of plants or parts of plants, leaving behind all the other soluble matter. There is every reason to believe, that the substance which flavours the distilled waters of vegetables is essential oil; because in most instances, a portion of essential oil, actually separates from the water, when recently distilled, because the sensible properties of the water are nearly the same, as when a few drops of the essential oil of the plant are mixed with pure water by simple agitation, because in the process of distillation the condensed liquor becomes gradually less and less flavoured, in proportion as the essential oil must escape, and because distilled waters, evaporated to dryness, leave no sensible portion of residue.

Common distillation of aromatic vegetables, is a simple process, but gives room for some nicety of management, particularly in the regulation of the heat, and the quantity of water, which can only be learnt by experience. As an example, common peppermint water may be given, and is thus made. Put a pound and a half of dry peppermint in a still, cover it with water, put on the capital, luting the joints with wet bladder or pasted paper, bring the liquor to boil quickly, and keep it just boiling till about a gallon of water has run over. The residue in the still is then thrown away as useless. The water that comes over first, is somewhat turbid, owing to the excess of essential oil that it contains, and in consequence, is by much the strongest. By rest it becomes clear, and a fine pellicle of oil rises to the top.

As a knowledge and choice of blossoms, fruits, and aromatic plants, used in distillation is important, we shall make some observations on these subjects, and conclude with a few directions for preparing distilled waters.

The distillers make use of blossoms on two accounts, viz. either to press out the tincture of them, as of violets, damask-roses, corn-flowers, saffron, hyacinths, pinks, &c. or to extract from them the volatile smell, as from the rose, carnation, jessamine, violet, jonquil: the blossoms of aromatic plants, as thyme, rosemary, basilic, spike-lavender, &c. or the blossoms of sweet-scented trees, as of lemon, orange, and others, are much used.

The distiller ought to know the choice of blossoms, and to make use of them only in their prime, and the time in which they have their full strength. The general rule is to gather them always before sun-rising, in clear, dry weather, whilst the cool of the morning prevents their volatile scent from dispersing.

The fruits made use of by distillers are of several kinds, lemons, oranges, golden-rennets, muscatel-pears, and quinces. From the quinces, which are fit to ferment, we may distil a spirituous water, which is very good to mix with other liquors, partaking of the fine flavour of that fruit, and contracting medicinal virtues for the stomach. This fruit is principally made use of for ratifias; which, after it has stood for some time, come to a very great perfection.

Cherries, plumbs, and apricots, are made use of in ratifias: these three sorts are infused in brandy. Distillers use other fruits to ratifias, as strawberries, raspberries, mulberries, &c.

Kernels of nuts are also used in distilling: those for ratifia are infused in brandy, when young. Bitter almonds serve the same purpose, as well for extracting oil from them, as for odoriferous essences.

Aromatic plants, are those whose stalks and blossoms have a penetrating, yet pleasing odour. These plants retain their scent, for a long time, after they are gathered, nay, even after they are dried. We

may extract from them odoriferous waters, and essences, which are used instead of the plant, when that cannot be had.

Spice is frequently made use of by distillers; such as, cloves, cinnamon, nutmegs, and mace. Out of these four sorts are extracted, by digestion, tinctures and infusion; and likewise oil, by distillation, as shall be specified hereafter.

The seeds generally made use of in distilling are, anise, fennel, angelica, coriander, dill, celery, parsley; of these are drawn the spirits, with brandy; and are well tasted liquors.

We shall here subjoin a few directions, for making such compound waters as are in most general estimation.

1st. *Clove-water:* Take 4lbs. of bruised cloves, half a pound of pimento, or allspice, and 16 gallons of proof spirit. Digest the mixture in gentle heat, and then draw off 15 gallons, with a somewhat brisk fire. The water may be coloured red, either by a strong tincture of cochineal, or of corn-poppy flowers; and sweetened at pleasure, with double-refined sugar.

The preparation of cordials or spice-waters, is very arbitrary; though after selecting your materials, as a general rule, follow the direction in the above article, keeping in mind that the quality of the liquor does not so much depend on the quantity or variety of the ingredients as on their judicious management.

2d. *Lemon-water:* Take of dried lemon peel 4lbs. pure proof spirit, 10½ gallons, and one of water; draw off ten gallons by a gentle fire, and dulcify the compound with fine sugar.

3d. *Citron-water:* Take of the dry yellow rinds of citrons, 3lbs. of orange peel, 2lbs, bruised nutmegs, three-fourths of a pound; clean proof spirit, 10½ gallons, and one of water. Digest them in a moderate heat; then draw off ten gallons, and add the requisite proportion of fine sugar.

4th. *Orange-water:* Take of the yellow part of fresh orange-peel, 5lbs. clean proof spirit, 10 gallons and a half; water, two gallons; and draw off ten, over a slow fire.

5th. *Double distilled orange-water.* Put orange blossoms into the still according to the quantity of water that is to be made, and having fire under it; draw over the flavour from the blossoms, re-distil this product with fresh blossoms, and you will obtain the double distilled orange-water.

With the double distilled orange-water you will have the essence, which is the oily part that swims on the surface. The essence is at first of a green colour, but changes in a few days into a reddish colour.

In order to part this from the water, turn it in a bottle; when the double distilled water will come out first, and the essence remain to the last.

6th. *Rose-water.* The common white roses are the best for distilling, while the red and wild roses are fittest for pharmaceutical purposes.

For distilling of simple rose-water, the leaves of the rose while fresh are slightly bruised, and then distilled, and re-distilled (according to the quality of the liquor required) as noticed in the preceding article.

Rose-water is generally distilled from the salted rose-leaves. The leaves, as they are gathered, are salted, in order to preserve them; and to every quart of the leaves, thus salted, about four quarts of water are added in the still. The distilled water is preserved by adding to it a small quantity of spirit: if it contract acidity, which is often the case in summer, it may be corrected by introducing into it a little potash or chalk. Rose-water may be prepared very expeditiously, by using the essential oil, commonly called the *otta of roses;* for this purpose it is first mixed with alcohol, and then added to distilled water; or it is put into the still with a small quantity of spirit and a sufficient quantity of water, and distilled. One drop of the oil, if the process be properly conducted, will impregnate one pint or even a quart or more of water: for it is only the impregnation of the water with the *aroma* of the rose, which resides in an essential oil, that constitutes rose-water. The double distillation of rose-water, as it is called, is intended (to use a technical phrase) to saturate the water with the essential oil, in order to impregnate it the more effectually. In order to unite essential oils with water, as may be practised also with the oil of roses, a method has been adopted, which answers in many cases as a substitute to distillation. This is accomplished in the shops of the apothecaries in the following manner: A piece of white sugar, about an ounce, is put into a mortar, and, for every quart of water that is to be made, ten to sixteen drops of the oil is added, with two ounces of alcohol; these are rubbed together; and the quantity of water gradually added. In this way is made the following waters, viz: of

Peppermint, mint, lavender, cinnamon, pennyroyal, &c. The waters sold in this

city as distilled, by the hucksters, such as mint, are prepared altogether of the essential oils. We shall notice, however, some of these waters as prepared by distillation.

7th. *Lily-water.* To make lily-water, take good blossoms, gathered in the manner as before observed, put them into a still and pour water on them.

Distil your ingredients with an open and pretty strong fire. Be careful not to bring over too much, lest the flowers should burn and spoil all; nor too little lest you wrong yourself.

To three quarts of water take one pound of lilies, or in proportion, if you intend to distil a larger quantity.

For the double distilled lily-water, fill the still half full with flowers, and put water to them. In this manner you will get a fine lily-water, and a beautifier to the skin. If you distil the lilies in a hot season, you will get an essence. When you draw over the double water, let it be only the fourth part, and the quintessence will swim on the surface, which, by decanting off the water, you will preserve in the receiver.

8th. *Of Carnations and Pinks.*—The carnations used by distillers are the small ones, which have only four leaves; and to make a good choice of them, pitch upon such as are of a deep red, terminating into black, of a velvet hue, and gather them in warm weather. These pinks blow thrice in the summer; the first blown are the best, for they are of more strength, and of a volatile smell.

When you have gathered your pinks, pluck off the leaves, and cut away the white end of them, which has no smell, and lessens the colour of the water. This done, put them into a stone bottle, and, when full, pour brandy to them; letting them, thus infused, stand for six weeks; then put some cloves to them, in order to extract the flavour from the leaves. In case you cannot get a sufficient quantity of pinks to fill a large bottle, take less, but be sure to fill it to the top; and then, but not before, pour in your brandy, and close it up, to prevent its evaporating, and lessening the odour of the flowers. After six weeks, pour the infusion through a sieve, and press the liquid gently from the leaves; add a small quantity of sugar, afterwards, filter and bottle it, and you have a beautiful tincture more valuable for its deep crimson colour.

9th. *Of the Jessamine.*—Part the blossoms from the green they are enclosed in, and use them soon, lest they lose some of their odour: put six ounces of them into your still, pour three quarts of brandy on them, and distil it with a pretty strong fire, care being taken to bring over none of the phlegm.

The spirits being all drawn over, close your receiver with a cork; then, having dissolved two pounds of sugar in fresh water, pour the syrup into the receiver, upon the spirits. This done, cork your receiver directly, and do not filter it till the next day, that it may have time to cool, and preserve its odour.

Cover the funnel whilst the liquor runs through the filter, and then carefully preserve it in bottles.

10th. *Of Violets.*—The single-violets in the spring are much preferable to the double ones in autumn.

Follow, in these, the directions given concerning the management of other flowers.

Having gathered your violets, part the blossom from the green, and put them in brandy.

The excellency of this flower consists in its beautiful colour and fine smell. Its colour both for syrup and liquid, is carefully extracted by infusion; and the value of either the one or the other is according to the beauty of its colour.

The violets having been for a month kept in infusion, pour the same through a sieve; dissolve sugar in water, and put the liquor of the infusion into the syrup, mixing both well together; after which, pour it through a filter and your liquor will be ready for bottling.

Flowers should be used as soon as possible after they are gathered, lest their volatile odour should escape.

11th. *Of the Jonquil.*—Select the single jonquils that have a fine odour, infuse them in brandy, as has been directed in the foregoing article; keeping the infusion in a moderately warm place. Then follow the directions given concerning the jessamine. It will be recollected that the principal use of the foregoing preparations is in perfumery, where, frequently the colour is of as much importance as the odour; but as this is generally destroyed where a considerable degree of heat is used, distillers resort to artificial means to supply this defect. The most usual colours in demand among perfumers, are crimson, cherry, rose, orange, lemon, purple and blue: these colours are prepared from turnsole, cochineal, and from the infusion of plants. 1. To prepare a crimson colour, take three drachms of cochineal and half a drachm of alum, beat them to an impalpable powder, add a wine glass of boiling water, and when well mixed, blend them with the syrup for the filtering operation. 2. To prepare a violet or

purple colour, turnsole-powder, treated similarly to the foregoing preparations, is alone sufficient. 3. For other preparations, select flowers of the colour you wish to impart, separate them from their impurities, put them with a small quantity of water into a pan or glass vessel, place the vessel in a sand-bath or over a moderate fire, and the blossoms will soon impart their colour to the water, which must be used like the first preparation.

12th. *Lavender and other herbs.—For four quarts of spirits of lavender, with rectified spirits of wine.*—Draw the spirits of seven quarts of brandy over by itself; then add four ounces of the essence of lavender, in the still, to rectify.

If you make use of the plant, then put half a pound of blossoms in, and as much brandy as before, to bring over the low spirits; and a gill of water, to *prevent* the ingredients burning at the bottom. When you have brought it over, add half a pound more of lavender to the distilled spirits, and rectify them without water.

Of the essence of lavender, or other aromatic herbs.

A distiller may be in a place where he cannot procure essences; he should then take off the blossoms from the stalks of such plants as he intends to use, (which must be cut fresh at sun-rise in warm weather;) spread the blossoms on a white linen cloth, and lay them in the shade for twenty-four hours; after which, stamp or bruise them; then immerse them in warm water, in the still, over a well covered fire, or hot ashes, and let them infuse for the space of five or six hours, without the head, yet so covered that nothing may exhale from it; after which, take off the covering and quickly put on the head, and lute it carefully. You must in the beginning draw over half the quantity of the water you put in. Take away the receiver and you will see the essence on the surface of the water, which you may separate from it, as you do that of the orange. Then put the distilled water back, and distil it over again, till no more of the essence appears on the water. Distil this water four or five times over, accordingly as you perceive the essence upon it.

The best distilling utensils for this work are those for the sand bath. You may also, after the common method, distil the ingredients on an open fire. But if you intend to make essence for waters, use common salt, in order to extract more from the blossoms.

13th. *Of the Essence of Spices.* To draw the essence from spice, is the most difficult task in distilling; for if it be extracted in the same manner as from aromatic plants, it will produce but very little; but in order to procure the greatest possible quantity, we proceed in the following manner:

Instead of extracting an oil, you make, for example, a tincture of cinnamon, (which approaches to the essence,) with rectified spirits, like the tincture of amber, nutmegs, and cinnamon: you first beat the cinnamon in a mortar to a fine powder, covering the same with leather, to prevent its escape: after which, you search it through a fine hair sieve; what remains, beat again in the mortar, and sift it as before. Then put the powder into a small still, and pour on it rectified spirit; stop it close with a cork, and secure it with melted wax. The spirits must be about two inches over the cinnamon. In this state of infusion you leave it for the space of fourteen or fifteen days, shaking it once every day; after which let it stand for some days to settle, then pour off the spirits as clear as possible.

You draw the essence from cloves after the same manner.

To make the Essence of Nutmegs. Take one pound, and beat them in a mortar, and they will become a dough, which spread on a new linen cloth, and put into a sieve: then put it over an ash fire, or make use of a kettle, or sauce-pan, of the size of your sieve, filling it about half full of water, so that, upon occasion, you may pour more to it. Your kettle must be pretty deep, so that the steam of the water may play freely, and the water when boiling, may not touch the sieve, but the steam may penetrate into the nutmegs. Cover the sieve close with an earthen dish or plate; then set it over a fire, till the dish is too warm to bear your hand upon it. The nutmeg is now prepared for drawing out the essence, for which take two smooth iron or copper plates, which heat to the degree usual for ironing of linen. Take the nutmegs, hot as they are, wrap the cloth around them, tie it with a strong cord: put it between the plates, under a press, and the essence will soon be discharged from the nutmegs. The water which may come along with the essence, separate as before directed, and you will have an excellent oil, or essence of that spice.

By the same method, the essence may be separated from mace and cloves; but to extract it thus, from cinnamon, is impracticable.

To draw the essence from spices, as from aromatic herbs or plants, take four pounds of them, with six quarts of water; but if you extract them over an ash

fire, or sand bath, then take only two pounds.

Of Seeds. Having under the preceding articles, shewn the method of distilling blossoms, aromatic plants, &c. we now come to aromatic seeds.

14th. *Of Anise-seed:* There are two kinds of anise-seed, viz. the Spanish which is of an excellent flavour, and is as large as a juniper berry, but yields very little in distilling; and the inland or green anise-seed, which if good is heavy, and though dry, retains its colour for a long time. This seed is best when green, or fresh gathered, and if bruised with a third part of fennel-seed, its quality is very much improved. To prepare anise-seed-water, put two quarts of brandy diluted with a small quantity of water, into the still; add one ounce of fennel-seed, and two ounces of anise-seed, distil with a gentle heat, and with what comes over, combine three quarts of water, and two pounds of sugar; then filter and bottle it for use.

15th. *Of Fennel, Coriander, and Angelica-seed.* To prepare water from these, individually, take two ounces of seed of each of the two former, and one ounce of the latter, and follow the directions laid down in the preceding article.

16th. *Juniper berries,* when new and fresh should be round, full, and of a black colour. If they are tart or sourish, in the flavour, moulded and shrivelled, they are of little or no value.

In order to make geneva, or juniper-water, first bruise the berries, and put them in a vessel wherein they may ferment, which they will do in a few days, and receive a spirituous and winy quality. When the berries have received sufficient strength, filter them and distil juniper-brandy, called geneva from them.

To make a cordial liquor from this ferment, bring the berries under the press, extract the juice from them; and distil it without apprehension of danger; but if you put the husks in, you run the danger of their rising up to the head, and stopping the entry of the pipe, which would occasion dangerous accidents.

17th. *Usquebaugh,* is prepared in the follow manner: Take of cloves, cinnamon, and nutmegs, each 2 oz. of caraway, anise, and coriander-seeds, each 4 oz. and half a pound of liquorice-root, cut in slices. Let these ingredients be bruised, and distilled with 11 gallons of proof-spirit, and two gallons of water, till the *faints* begin to rise. When the liquor is about to *run,* 2 oz. of British saffron, tied in a linen bag, should be fixed to the extremity of the worm, so that the spirit may filter through, and extract all the virtues of the saffron. When the distillation is completed, the whole should be sweetened with a sufficient quantity of double-refined sugar, and decanted for use.

18th. *Common ratafia,* is obtained by infusing 2 oz. of nutmegs, 2½ lbs. of bitter almonds, 2 lbs. of Lisbon sugar, and 2½ grains of amber-grease, in ten quarts of clear proof spirit. It will be proper to bruise the nutmegs and almonds; and also to triturate the ambergrease with the sugar, in a mortar, before they are added to the other ingredients; and, when the whole has digested for a sufficient time, it may be filtered through a bag, and kept for use in close vessels.

Red Ratafia: Take 24 lbs. of *black-heart cherries,* 4 lbs. of the *common black cherries,* 3 lbs. of raspberries, and the same quantity of strawberries, which must be deprived of their stalks, and then bruised. In this state, they are to remain for the space of 12 hours; when the juice should be expressed, and a quarter of a pound of sugar be added to each pint. As soon as the latter is completely dissolved, the whole ought to be filtered, and mixed with three quarts of clear proof spirit. Next, one ounce of cinnamon, two drachms of mace, and half a drachm of cloves, are to be bruised, and poured into an alembic, together with two pints of spirits, and one pint of water: one quart of spicy spirit should be drawn off with a brisk fire, and be added to the liquor: when the whole has properly subsided, it may be decanted for use.

Dry, or sharp Ratifia: Take 30 lbs. of cherries, a similar quantity of gooseberries, 7 lbs. of mulberries, and 10 lbs. of raspberries. These fruits must be cleaned, picked, and bruised; after which they should be suffered to stand for 12 hours. The juice is then to be expressed, and combined with three ounces of sugar to each pint. When the latter is dissolved, the liquor must be filtered, and four pints of pure proof spirit mixed with every five pints of the former, together with the same quantity of *spicy-spirit,* as directed for Red Ratifia.

Of Infusions. Infusions have been treated of, in several of the foregoing receipts: they were made use of before the distilling of liquors was well known, and commonly done in spirits of wine, which method is still observed by many people: and although distillation is far preferable to infusion, yet the latter ought to be well known and practised, on several accounts; first, for the satisfaction of such as have an aversion against distilled liquors, 2dly, as it is an essential part belonging to the art of distilling: 3dly, as it is a means for procuring things in such places where no

utensils for distilling are to be had: And, lastly, as we may perform all that, without apprehension of danger, which we cannot draw over the helm, where, of necessity, recourse must be had to infusion.

By infusion we understand a steeping of any kinds of drugs, roots, leaves, &c. in some liquor proper to draw out their virtues.

Several infusions are made in water for syrups, and medicines, some are made in wine; others for strong liquors and ratifias, are infused in brandy, and spirits of wine.

The ingredients are put into a vessel that can be well covered and enclosed. They are either pulverized, cut, or left whole, in the same manner as though they were to be distilled; they are continued in infusion, for from fourteen or fifteen days, to a month, six weeks, or two months, and shook about every two or three days; after which the liquid is gently poured off the ingredients, then mixed with syrups, prepared for that purpose, filtered and bottled for use. The infusion of spices may be performed in eight or nine days: others, for extracting of colours from blossoms, require only twenty-four hours. The aromatic herbs are usually infused in alcohol or spirits.

The right method for making infusions, is to put them in cool places, except it is for extracting the colours out of blossoms; when a moderate heat becomes necessary.

The following circumstances are chiefly observable in common distillation.

The substance from which the distillation is made in some cases requires previous treatment, in others none. The petals of flowers, such as roses or jessamine, may be used immediately or only after the gentlest drying. The aromatic herbaceous vegetables, such as peppermint, may be used indiscriminately fresh or dry, observing that the plant is much more watery when fresh than when dry; more water may be added in the distillation of the latter, than of the former. Hard woods should be rasped or bruised, and as they are less easily penetrated by the water, they should be macerated in it without heat, from one or two days, to as many weeks, before distillation.

The quantity of water to be used varies much according to circumstances. It should be always so much as during the whole process to cover all that part of the still which is immediately over the fire, otherwise, the vegetable matter will scorch, and give a very disagreeable burnt taste and smell, or *empyreuma*, to the distilled liquor. On the other hand, too much water makes the distilled liquor unnecessarily dilute. In general, fresh vegetables require about thrice their weight of water, and when dry, five or six times. The still should never be more than about three-fourths full, or even less, when succulent vegetables are used, to prevent boiling over.

The management of the fire is of some consequence, to prevent boiling over and empyreuma on the one hand, and on the other, to give heat enough for extraction of the aromatic principle. Where a water bath is used (which, however, is tedious. and seldom if ever necessary) all danger of excess of heat is avoided; but, it is often requisite to encrease the heat of the bath by adding salt to the water. When, in distilling without a bath, too much heat is used, there is danger either of blowing off the capital, not without risk to the bye-stander, when the liquor boils with extreme vehemence (which is particularly likely to occur, when the still is too full of bulky herbaceous vegetables, that rise in the capital, and partly choak up the opening into the worm-pipe) or else the liquor boils over into the worm-pipe, and mixes a *decoction* of the vegetable with the distilled water. This is soon perceived by the condensed liquor coming out at the bottom of the worm, not in a clear uniform streamlet, but by gushes and starts, with a gurgling noise, and fouled or coloured. When this accident happens, the fire should be entirely slacked, the capital taken off, the liquor already come over, returned into the still, and the distillation begun again with more care. When the stream of distilled water flows evenly, and the boiling liquor is heard to simmer moderately in the boiler, the operator will know that the process is going on properly.

The quantity of aromatic water, to be obtained from a given weight of any vegetable, cannot be laid down with accuracy, so as to obtain a liquor of uniform strength; as, (independently of any difference in conducting the operation) the season of the year, the length of drying, and other causes, will materially affect the intensity of aroma in the vegetable. The taste, therefore, is a better criterion to judge when to stop the process, as the liquor will run nearly tasteless, long before the water has all boiled away. Some advantage is gained by mixing all the distilled liquor together, as the first portion has generally rather more essential oil than it can retain, and the last portion has less.

Some other observations relative to the management of distillation, will be men-

tioned under the article of OILS *Essential*, which are mostly obtained by the same process.

Distilled waters are generally supposed to be made much stronger by *cohobation*, or redistilling the same water from fresh materials. No very accurate experiments have been made on this subject; and, it would appear, that when water is the first time so supersaturated with essential oil, as to let go a portion by mere subsidence, no further process can make it take up more. If so great an increase of sensible and other properties is really produced by cohobation, as is usually allowed, it would render probable the old opinion of a *spiritus rector*, or a peculiar principle in which the active and odorant particles reside, separated from, and independent of the essential oil, and which is most largely disengaged at the first impression of heat, and soluble in water, already saturated with essential oil.

The greater number of those liquors, commonly called *Distilled Waters*, *Cordial Waters*, &c. are prepared by the particular vegetable, distilled with ardent spirit, more or less diluted.

The simple waters, such as are extracted from orange-blossoms, or lavender, and other aromatic plants, are valuable; since by them we may give their respective flavour to other liquors and things, and, by that means, save abundance of labour, pains, and expence.

The simple waters of orange, lemon-peel, and others, are not only used by perfumers, but they are also of use in the kitchen, for making of ragouts, &c. There are waters also distilled from thyme, sage, chevril, parsley, sorrel, and other kitchen-herbs, which retain their natural flavour, and supply the want of them in the winter season.

We know, by experience, that distilled waters of spices have more odour and volatile essence, than the spices themselves; for the distillation frees them from the gross parts, and a superfine spirit is thereby extracted, whereof two or three drops, according to the quantity of meat, or sauce, to be seasoned, will be of more effect than seasoning it with a larger quantity of the spice itself. The *spirit of spice*, is principally useful in sauces and meats, that are of a transparent and clear nature, which, by the solid spices, are rendered thick and obscure.

DOG. See ANIMALS DOMESTIC.

DRAGON'S BLOOD, is a red-coloured, inodorous, and insipid resin, insoluble in water, soluble in alcohol and in oils, to both which liquors, it communicates a red colour. By fire it is fusible, inflammable, and it emits an acid vapour, like that of benzoin. A solution of dragon's blood in alcohol, is used for staining marble, to which it gives a red tinge, which penetrates more or less deeply, according to the heat of the marble, during the application. But, as it spreads at the same time that it sinks deep, for fine designs the marble should be cold. Mr. du Fay says, that, by adding pitch to this solution, the colour may be rendered deeper. It is also used, in considerable quantities, in many coloured varnishes, and to give a mahogany colour to white wood; if mixed with a small portion of gamboge yellow, it much improves the tint, rendering it more deep and rich.

DRAINING, is the art or practice of making artificial channels, for carrying off superfluous moisture or water, from wet or marshy lands.

Those lands to be drained, are usually divided into two classes: 1. *Uplands*, or those which are situated so high, that the water can descend from them, if properly collected and conducted; and, 2. *Fens*, *marshes*, or those lands which lie so low as to command no fall; have no descent; and some being even below the level of the sea.

1. With regard to *uplands*, it generally happens, that the waters from the springs beneath the soil are obstructed in their course to the neighbouring rivers. These springs originate from the atmospheric moisture; which, being condensed on the summits of hills into water, by the greater coldness of those parts, perforates the different strata of the incumbent soil, where it is of a porous nature; the water continues to descend, sometimes for many miles together, but generally from the nearest eminences into the adjoining valley, till its course is intercepted by a stratum of clay; where, being collected in considerable quantities, it is forced to work itself a passage through the porous strata of sand, gravel, or rock, that may be above the clay, following the course of these strata, till they approach the surface of the earth, or are interrupted by any obstacle, which causes the water to rise to the surface, and to form springs, bogs, marshes, &c.

At the foot of hills, therefore, where the plain begins to be too moist, some augur-holes should be bored, in order to find the depth of the springs, and consequently the thickness of the upper stratum of the soil. If this be only 4 or 6 feet, an horizontal ditch should be cut along the bottom of the hill, to intercept the water, which ought to be carried off by one or more ditches communicating with the for-

mer, and conducting the water thus collected, into the neighbouring rivulet. Further, as the strata, through which the water descends in forming these springs, have, with a few exceptions, the same inclination as the surface of the hill, the holes should be bored, and the ditch cut, not vertically downwards, as is commonly practised, but perpendicularly to that surface, or in other words, they should be formed perpendicularly to the side of the mountain, and not perpendicularly to the horizon.

If, nevertheless, on cutting a ditch five or six feet deep, along the foot of a hill, vertically to the rising plain, the upper stratum be not penetrated, and consequently no water ooze into the bottom of the ditch, it will be expedient to bore other holes at the bed of such ditch, some yards deeper, or till water ascend through them. Where this succeeds, many holes should be made, and the water conducted into the adjacent brook, or river; for it will then rise, collect in those trenches six feet below the wet surface of the valley, and thus be carried off, instead of rising up from the lower *wall-springs*, or apertures of the stratum, through the incumbent soil, to the surface of the valley, which is so many feet higher.

Situations, however, frequently occur, where the first stratum of the earth may be too thick to be easily perforated; or where the water, condensed from the atmosphere on the summits of the hills, may work itself a passage between the second and third, or between the third and fourth strata, which form the sides of those hills, from a deficiency of so many of the strata at their summits. Hence the water lies too deep to be retarded in its progress by a ditch, or by boring; but, being dammed up by the materials that form the plain of the valley, it ascends through them to the surface, and thus forms boggy, or marshy ground. In such cases, the common mode of draining may be successfully employed: it consists in cutting several ditches four or six feet across the bog, or morass; and in covering them so that the water may not be obstructed in its passage, but be thus in part collected and conveyed away, though certainly with less advantage than where springs can be intercepted.

Another method of draining is, that of opening trenches, or drains, almost annually, by a large plough with two converging coulters, and other appropriate machinery, for the purpose of cutting both sides of a ditch at the same time, and turning out the intervening soil.

II. With respect to the draining of those *plains* or *morasses*, where no fall can be procured, the water may, in many situations, be collected by cutting a long horizontal ditch above the level of the morass, so as to intercept all the wall-springs; and may then be carried off in wooden troughs, or hollow bricks, above the surface; and, if any water continue to penetrate the morass, it may be conducted to the extremity of the ground, either in open or covered drains.

The draining of low moist lands may also be advantageously effected by a *roller* or *wheel;* for an account of which see AGRICULTURE.

The necessity and utility of draining the surface water from *clay soils*, in wet seasons, is generally acknowledged; but, excellent as the different methods are in the cases before mentioned, they do not appear to be so simple, or so effectual, as could be wished in the present. Covered drains frequently fail in producing the desired effect, in consequence of the covering materials being of too close a texture to admit the water to filtrate through them with sufficient freedom. Mole-ploughs, of the best construction, require such a number of horses to draw them, as must necessarily injure the soil, by *poaching* it. Farther, *covered drains* are not only dangerous to cattle, but from the quantity of clay necessarily dug up, and spread over the richer surface-soil, they are also injurious to vegetation. None of the several modes of draining now in use, being subservient to the essential purpose of conducting large quantities of water, from a deep soil, we feel satisfaction in communicating the following simple contrivance of Mr. John Middleton, just published in the 22d No. of the "*Commercial and Agricultural Magazine.*" It consists merely in adding a piece of wood to the felly of a common six-inch cart-wheel, to which is prefixed a rim of iron, of a triangular form. The whole expense of this addition does not exceed one guinea. A wheel of this description, when put on the axle of a cart in the usual way, will of course rest on the edge of the triangular rim of iron, above alluded to; and, on driving the horses forward, will make a small indent on the ground, merely by its own revolution. But, in order to press it down, to the depth of six or eight inches, that side of the cart should be laden with stones, iron, or any other heavy material, until the whole of the rim, as well as the additional piece of wood, and the felly itself, if necessary, sink into the soil. The cart should then be drawn in such a direction that the cutting-wheel may revolve where the drains are intend-

ed to be formed. Sometimes it will be necessary to apply the indenting machine to every furrow; but, where the land is level, it should be drawn over it in parallel lines, five or ten yards apart. The wheel on the opposite end of the axle is a common six-inch wheel, which supports only the empty side of the cart, and consequently will not cut the ground.

The advantage of this contrivance, as stated by Mr. Middleton, is, that it makes an indent in the soil, sufficient to carry off the water during the ensuing winter, by pressing down the herbage, without destroying it. In the succeeding spring, these drains will be nearly grown up, so that there is no injury done to the grass. He observes, however, that this wheel should be drawn over the ground every year, on the approach of winter; but so easy is its application, that by means of it, and two old horses, one stout boy, or man, may drain from *ten to twenty* acres in *eight* hours.

The first object in draining a bog or marsh, is to discover the lowest spot of dry ground that surrounds it, in order to open on that part the main trench which is to carry off the water: if there be the least appearance of any stream, it should be traced with care; for this will point out the proper spot on which to begin. The main trench, commencing at the lowest part, may be carried to whatever distance it is thought proper; if it begin at the right spot, ten acres may be detached from the marsh, however extensive, and completely drained; but, if the drainage be not begun where there is a sufficient fall, the labour bestowed will be to no purpose: the main cut or trench should be ten feet broad in the clear, with a proper slope, to prevent the sides from falling in, and filling it up.

Bogs are divided into two sorts, *black* and *red*. The former are solid, and make excellent fuel for common fires, or burning lime; but the red bog consists of a loose, porous, fungous mass, which burns badly, and yields no ashes. Hence, in black bogs only, the drains ought to be cut into turfs, dried, carted, and piled.

As the main canal advances, small ones may be conducted into it, on either side, inclosing such spots of ground, as are intended to be improved. No certain rule can be laid down for the depth of drains; yet we apprehend the prevailing practice of cutting them down to the solid ground, beneath the bog, is founded on the erroneous principle, that such depth is sufficient as will leave the surface dry. Numerous drains, however, being always useful and necessary, the spots inclosed ought not to contain more than five acres; but in such space it is requisite that several cross-cuts be made, which should be four feet broad at the top, and three feet deep. A whole year will be requisite to complete these drains; and, in the ensuing spring, it will be necessary to open, deepen, and clear them of the adventitious boggy matter; a work which should be occasionally renewed. The second year may be employed in extending the main trench; in taking in fresh inclosures by new lateral cuts; and in draining these by means of small transverse drains. Although this annual deepening and clearing of marshy grounds be attended with great labour and expense, yet the operation is thus progressively completed, and in succeeding years both trouble and costs will be gradually diminished, in proportion as the bog subsides.

As soon as the drains have rendered the marshes sufficiently firm for oxen to walk on them, the heaviest rollers that can be procured should be employed, to act by repeated pressure. Indeed, without a considerable degree of such pressure, during the first year, no bog can be effectually consolidated. An alternate draining and rolling, annually (the drains being still kept open,) would, probably, contribute much to the destruction of weeds. Previously to rolling in the spring, it has been strongly recommended to sow every kind of grass seeds, indiscriminately, such as ray-grass, hay-seed, clover, &c.

Before we conclude this subject, we think it necessary to give some account of *stone drains*, which are calculated for soils where the common methods of draining cannot be adopted. Such drains ought to be cut 10 or 12 inches wide, with perpendicular sides; and flat stones should be so placed, as to leave a water-course at the bottom, by setting two stones triangularly to meet at the points. Or, the bottom may be covered with a flat stone, and three others placed upright, and the water left to work itself a passage between them. In either case, the cavity of the drain ought to be filled nearly up to the top, with loose stones: screened or washed gravel, where it is found in great abundance, has been successfully substituted. Those pebbles, however, which are often found on the sea-shores, are well adapted for filling drains; as, being smooth, and generally round, the water flows through them more freely

The principal drains ought to be three feet deep, and 18 inches in width; the bottom and top should be laid with flag-

stones; the sides built up to a sufficient height with common stones; and the whole covered with sods of turf, but the grassy sides downwards: these again are to be overspread with earth, sufficient to admit the plough. The smaller drains are, in general, to be conducted at an acute angle into the main trenches.

Lastly, *sod* or *earth-drains* are usually dug two feet deep with a spade, when the soil is taken out by an instrument, or scoop, about four inches wide, and the drain covered with sods first dug out, if the ground be firm enough to support them; or, some black-thorns are put in, in order to bear the weight of the sods. Those drains which have the smallest passage for the water at the bottom, are reputed to be the most durable; as the force of the water has been found sufficient to clear away any small obstacles, accidentally obstructing its course.

Common earth-drains, are sometimes dug two or three spits deep, with a broad spade, the bottom is taken out with a narrow one, and filled with stones. Sometimes a furrow is drawn with a plough, and cleared by a common spade: the draining instrument, (which is a long, narrow, pointed spade, terminating in an acute angle, in the form of a wheat leaf) is then introduced, to the depth of 18 inches from the surface; and, after taking out the loose mould with a scoop, or spade, black thorn bushes, or heath, which is still better, are carefully laid along the bottom, covered with strong wheat-straw, twisted to the thickness of a man's leg; and the whole is then carefully closed in.

Hollow drains, without stones, have been tried on stiff lands: they are made narrow at the bottom, and covered halfway up with sods, or square pieces of the surface-sward, resting on ledges, cut for that purpose.

Those who wish to acquire more minute information on this subject, we refer to Dr. Anderson's excellent *Practical Treatise on draining bogs and swampy grounds*, 8vo. p. 308; and to Mr. Johnstone's *Account of the most approved Mode of Draining Land*, &c. 4to. in which it is amply investigated. See also AGRICULTURE.

DRILLING, in husbandry, a method of sowing grain, or seed of any kind, so that it may be deposited in the ground at an uniform depth; a circumstance of the utmost importance to the production of healthy and vigorous plants.

This method differs from the old, or broad-cast husbandry, which is performed by sowing the grain, or seed, with the hand; whereas, the new practice is effected by one of the most useful machines ever invented, and called a *drill plough*.

By the broad-cast system of culture, the land is often sown in bad tilth, the seed is always scattered at random, and sometimes by very unskilful hands. In drilling, the ground must be in good order; and the seed set in trenches regularly drawn, all being nearly of an equal depth, which is adapted to the nature of each particular kind of seed. These seeds are also distributed at proper distances; and, by being equally and speedily covered, are most effectually protected from vermin, and other accidental injury. Farther, in consequence of the broad-cast practice, the seed falls in many places too thick; in others, too thin; and, being imperfectly covered, part of it is devoured by vermin, which follow the sower; the remainder is exposed to rain or frost, or to heats, either of which are very hurtful. When harrowed in, a considerable portion of the seed is so deeply buried in the soil, that if the latter be wet, it putrefies before it can vegetate.

Besides, when corn is thus sown, the crop will not admit of being touched afterwards, because its growth is irregular. The soil cannot be broken, in order to afford it more nourishment; nor can even the weeds be destroyed without much damage and inconvenience. On the contrary, in the drill-husbandry, the intervals between the rows, whether double or single, may be horse-hoed; and nourishment may thus be repeatedly given to the plants, and the weeds almost totally extirpated. Drilling, however, is not calculated for *every* soil; yet, as there are but few situations, in which the broad-cast method is preferable to it, they ought not, by any means, to impede the more general introduction of the former.

The drill-husbandry is said to be attended with many disadvantages: namely, 1. That it is very difficult to procure the persons, who are acquainted with the use of the drill-plough, or its proper management, when on the soil. 2. That the earth requires to be well prepared to admit of it. 3. That the crop is too thinly sown by it. 4. That drilled crops are harvested later than broad-cast ones. 5. That clover does not succeed, when cultivated according to the drill-husbandry. 6. That oats produce rank and coarse straw, which does not afford wholesome food for cattle.

These objections appear formidable; and it must be allowed, that no person can acquire a thorough knowledge of the drill-husbandry in one season. It is nevertheless untrue, that the seed is too thinly

sown; for, though the quantity required is nearly one half less (which is consequently saved), yet the crops of drilled wheat are, in general, so much more valuable than those of broad-cast, whether we consider the quantity, quality, or weight of the grain, that the inferiority of the latter is evident to every impartial observer. This reason is likewise a sufficient answer to the objection alledged against the expence of horse-hoeing, which eradicates almost every weed, even where hand-hoeing is impracticable; and, consequently, in a very considerable degree, promotes vegetation.

To this, we may add, that by drilling, the seed grows more regularly and vigorously; and that, though the crops are harvested later than broad-cast ones; yet, they are *gotten in* with less expence, and with greater safety; while the soil is left in a better state for future crops.

Such are the advantages, and disadvantages, attending the drill-husbandry, which we have endeavoured fairly to state: after these decisive proofs, no rational agriculturist will hesitate to pronounce in favour of the new system.

One of the earliest implements of this description, is the *hand-drill*, which is chiefly employed in the low-lands of Scotland, where it was also invented. It is pushed along by two handles, in a manner similar to wheel-barrows, and sows one row at a time. The principal part of this machine is a wheel, about 22 inches in diameter, and made of solid deal, upon the axle of which is fixed a notched roller 2¾ inches in diameter, and 2 inches long, that turns in the fore part of the drill-box. The quantity of seed intended to be sown, is regulated by a slider, which moves up and down in the fore-part of the box, by an adjusting screw fixed at the top; and has a strong brush, that projects from its lower end, and sweeps upon the notched roller. There is also a sluice, or slider, which lies flat on the bottom, on the inside of the drill-box, and juts out between the two handles of the drill, so as to be within the reach of the person guiding it; who, by pushing the slide forwards, completely covers the notched roller, and prevents any of the seed from being scattered, while the drill is turning at the end of the ridges. With this implement, a woman, or boy, is able to drill from 2 to 2½ acres in a day; the rows being at the distance of 20 inches.

The next contrivance, is that of the ingenious Mr. Arthur Young, whose indefatigable labours in promoting agriculture, are too well known to require our encomium. In the common drill-ploughs, there are generally two or three barrels with corresponding hoppers, or receptacles for seed, through which it is committed to the ground. Such an arrangement renders them necessarily complex; and to obviate the defect resulting from it, Mr. Young has two divisions in the barrel, and two corresponding ones in the hopper, which are more simple, and doubtless preferable to moveable boards. In his drill-plough the whole machinery is fixed, yet he sows with it single rows at any distance, double ones at two feet, or three rows at one foot; relinquishing the other powers of mechanism, to render the plough in all its parts stronger, and more steady. It is likewise calculated for the stiffest soil; and Mr. Young adds, that it it will even deposit seed in drills cut through a clay field, without any previous ploughing.—For a more detailed account of this excellent machine, as also of several others, we refer our readers to the 3d vol. of "*Annals of Agriculture*."

Before we conclude this highly important subject, it will be useful to state the extraordinary saving that would arise from a general introduction of the drill-husbandry. Indeed the patriotic Lord Somerville, late president of the board of agriculture, in England, whose exertions in promoting that beneficial science, must endear him to every friend of his country, has already anticipated our calculations. Though bred to the broad-cast method, which he till lately followed, that enlightened man, has, in the appendix to his interesting work, entitled, "*The System followed during the two last years by the Board of Agriculture*," &c. (8vo. pp. 300, Miller, 1800), impartially exhibited the great advantages that might result from the national adoption of the drill-husbandry.—We regret that our limits will permit us only to extract a few leading circumstances from his publication. In order to ascertain, beyond the possibility of doubt, the infinite superiority of the drilling, over that of the broad-cast method of sowing, he applied to three gentlemen alike eminent for their agricultural skill, and each of whom made use of different drill-ploughs. From an accurate statement it appears, that the expences attendant on the old and new practices, are as follow:

Expence of seed-corn on 133 acres of land, sown in the usual broad-cast husbandry in 1799, was	*Sterling.* L. 134 10 6
The expence of seed-corn for the same number of acres, according to the present improved system of drilling,	100 4 6
In the year 1800, the expence of 140 acres broad-cast, was	216 10 0
Ditto, ditto drilled,	92 0 0
Which affords a saving of not less than in seed-corn on 140 acres of land.	124 10 0

Both estimates were made from actual experience, by the industrious Mr. Budden, and communicated to Lord Sommerville, by the Rev. H. J. Close, of Hordle, near Lymington, England; from whose letter we insert the following computation of an *annual saving* that may be effected by the uniform practice of the drill-husbandry; and which, at a moderate calculation, will amount to no less than *eight millions* of bushels of wheat, *one million* of bushels of rye, *three millions* of bushels of barley, *four millions* of bushels of oats, and *one million* of bushels of beans and peas !

Having, however, in the course of attentive observation, during the last twenty years, witnessed many disappointments, both in *statistical* and *political* schemes, we are not so sanguine in our expectations, as to place implicit confidence on any general statement, especially when it is exemplified by *round* numbers. Nevertheless, in justice to the zealous supporters of the drill-plough, we fully admit its superiority over the clumsy and irregular practice of the wasteful broad-cast husbandry; and posterity will ever gratefully remember the names of Tull, Cooke, Young, and Darwin, if, by their joint labours, *one half* of the above stated quantity of grain and seeds, that is, together *eight or nine millions of bushels*, could be *annually* saved to the English nation, before one half of the present eventful century is expired.

DRYING OIL, is oil prepared by boiling oils, such as linseed, with litharge, and is the basis of a vast number of paints and varnishes. If the naturally drying oils are boiled upon litharge without the intervention of water, they become thick, glutinous, and more drying than before. Not only the oxids, but also aqueous solutions of the acetite of lead, as well as the sulphat of zinc, are employed for this purpose. See OILS.

DYEING. *The Art of.*—The object of this ancient and truly chemical art is to fix uniformly and more or less permanently, certain colouring matters into the fibres of wool, linen, cotton, silk, and other filamentous substances.

The operations of dyeing, from the preparation of the stuff to that of the colour or dye, and some subsequent processes, are so completely chemical, that however the dyer may consider his art mechanical, a knowledge of chemistry seems indispensably necessary. Although it is well known, that few who practise dyeing in this country are skilled in theory, and those only are confined to the production of a few colours, yet we have known, that a dyer well acquainted with chemistry has made more progress in the advancement of his art, than at first view would be supposed. The person, to whom we allude, is MR. PARTRIDGE, now principal dyer to the Messrs. Duponts' of Brandywine. He has not only employed a number of indigenous plants, but has invented new mordants, so that many colours, for which we were heretofore indebted to Europe, we obtain from our own resources. DR. PENNINGTON, in his Chemical and Economical essays, by turning his attention to this subject, has recommended several vegetable astringents for the production of black dye.

These facts are designed to shew, that to those engaged in extensive manufactures, where dyeing forms a necessary part, much may be accomplished not only in discovering new colours, but in using new mordants, or certain bases suited to the stuff and the colouring ingredient. We have seen, however, with great satisfaction, that the art of dyeing has kept pace with the progressive improvements of the other arts; but we have found, that in every case where a new colouring matter or a new mordant was to be used, considerable time has been wasted in a number of vague experiments, which, from their being unchemical, have served to perplex and confound the operator.

In families we find, that mixed colours have been hit upon, for dyeing their domestic articles, without any chemical knowledge whatever, and very often alum, chamber-lie, &c. are employed without knowing their use; but the case is different on a larger scale, though probably from chance the manufacturer may succeed, yet the risk and the considerable expense he incurs are, too frequently, objects of much importance. we would,

therefore, recommend to the professional dyer, to acquire a thorough knowledge of chemistry as connected with dyeing.

A detailed account of all the processes of dyeing would of itself fill a volume: in this place therefore all that can be done will be to give a short view of the leading facts and operations.

The substances commonly dyed are either of animal or vegetable origin. To the former belong wool, silk, hair, leather, and skin of all kinds; to the latter, cotton, flax and hemp. The particular chemical analysis and properties of these substances, as far as they have been examined, will be described under the respective articles. A most important and essential difference exists between the affinity for colouring matter possessed by these substances, so that a process which perfectly succeeds in dyeing wool (for example) may have no effect upon cotton, neither is there any agreement in the quantity of colouring ingredient necessary to dye each stuff.

A simple experiment of Dufay's proves this. He had a piece of cloth woven, of which the warp was wool, and the woof cotton, this was fulled that each substance might undergo exactly the same preparation, and then passed through a scarlet vat. The wool only took the colour, but the cotton remained white after rincing. With regard to quantity of colour, it is found that silk takes twice as much cochineal to dye it, as wool does. The different force of affinity between different fibres and colouring matter is also shewn by the more or less perfect manner in which they exhaust a coloured bath; thus, as Bergman observes, wool dyed in a weak solution of sulphat of indigo entirely absorbs the dye, and leaves the solution colourless, whereas silk can only partially rob the sulphuric acid of the colouring matter. Generally speaking, wool has the strongest affinity for colour, taking it more easily, and retaining it more firmly; silk and other animal matters come next to wool, cotton next, and hemp and flax last; but this is not to be understood with great latitude, nor does it always happen that substances which take colour the easiest, retain it the longest, besides that the previous preparation is not the same, and hence the comparison is not altogether accurate.

No exact explanation can be given of the different affinity for colour in different substances, except that the analysis of vegetable and animal matters shews a most essential difference in their component parts, and their habitudes with chemical reagents. It is on this account too, that the preparation, which each substance receives previously to being dyed so much varies. Animal matter, especially wool, when immersed in caustic alkali has its fibre immediately relaxed, becomes clammy, loses its natural toughness and elasticity, and at last is entirely dissolved in a soapy compound. Vegetable fibre on the other hand resists alkalies much longer, and is not easily dissolved; and hence in the previous cleansing and fulling of wool, alkalies are scarcely admissible, or must be used with extreme caution, whereas they may be employed with safety in the preparation of cotton and linen. Animal fibre is also much more easily affected by acids.

The simple colours employed in dyeing are chiefly of animal or vegetable origin. The number of possible dyes is almost equal to that of the vegetable or insect tribes on the face of the earth, for almost all of these will make a coloured decoction with water, which is capable of tinging cloth immersed in it. Hence the variety of native dyes from indigenous plants used in different parts of the globe by every nation, savage, or civilized. A very few, however, are employed in the regular manufactories of European nations, being such as are obtained in the most abundance from countries where they form valuable articles of commerce, and whose qualities are minutely known, by long and accurate observation.

Of the great variety of known dyes, some, (though comparatively but few) may be applied to animal or vegetable fibre without any other preparation than that of cleansing the stuff, and immersing it in a decoction or infusion of the dye for a sufficient time. The colouring matter then unites with the fibre of the cloth with a greater or less degree of force, so as sometimes permanently to resist the effect of washing, and the bleaching power of the sun and air, sometimes partially, sometimes scarcely at all. On the other hand the greater number of dyes have naturally only a very feeble affinity for fibre, (though never in the same degree for animal and vegetable) and therefore, when applied without addition, they are destroyed very speedily; but the ingenuity of man has discovered that they may be made to unite with fibre much more durable by the intermede of some other substance (generally a salt with an alkaline, earthy, or metallic basis) which possesses a very strong affinity both with fibre and with colouring matter, and hence serves to bind the one to the other. These intermedes are called *Mordants* (a term derived from an erroneous theory

now abandoned) and the usual practice is first to steep the cloth or fibre in the mordant, and afterwards in the dye.

The dyes that cannot be fixed into the stuff without mordants may be termed (with Dr. Bancroft) *adjective* colours; those in which mordants are of no use may be called *substantive* colours. Madder is an adjective colour, since it is rendered much more durable by the intermede of alum, or of many other salts than when used alone. Indigo is a substantive colour, since its durability is not encreased by any intermede whatever.

Another important difference in the nature of dyes is in the degree of permanency of tint, which certainly in part depends on the force of affinity with which it unites to the fibre, and partly on the intimate nature of the colouring matter, and its susceptibility of decomposition by light, air, moisture, and also by alkalies, soaps, and other substances employed in the common uses of dyed stuffs. The permanency of colour has no necessary connexion with the mode in which it is united to the substances dyed, for among the substantive as well as the adjective colours some are very permanent, others very fugitive. For example, of the substantive colours (or those which unite as strongly to cloth without, as with mordants) *Indigo* is very permanent, resisting the sun, air, washing with soap, and most chemical agents: the oriental *Henne*, which is a fine orange red, long resists the sun and air, but is altered and destroyed by soap: *Archil*, and other of the purple lichens, is instantly altered by soap, and is soon changed by the light and air, so as only to give a very fugitive but beautiful gloss. Of the adjective colours *Madder* is one of the most permanent that is known, retaining its body of colour (when well applied) under almost every circumstance. *Cochineal* on wool is nearly equally fast or permanent, but on cotton much less so; *Brazil Wood* fades much sooner than the last, whatever mordant be applied.

The selection and right application of mordants is of infinite consequence in dyeing, and it is this subject, with its various modifications that forms the truly scientific part of this beautiful art. Linen or cotton requires a different mordant from wool or silk, some colours adhere only to a particular mordant, the order of application, the strength, and many other smaller circumstances, all of which materially affect the beauty and durability of the colour, and the texture of the cloth, must be attended to by the artist.

Some simple experiments related by Dr. Bancroft, and which are readily repeated, well illustrate the action of mordants. A piece of cotton was impressed with various figures with a mordant of acetited alumine, and when dry was rinced and cleansed in the usual way of calico printing. It was then dyed in an infusion of saffron and came out uniformly yellow, but on exposure to air the whole became white. Hence it is shewn both that the colouring matter of saffron has no strong affinity with cotton, and that alumine has no power of fixing it, and hence is useless as a mordant. The same piece was then dyed with a decoction of Brazil wood, and the whole came out coloured, but the figures printed with the aluminous solution were of a fine crimson, whereas the ground was only faintly tinged. On exposure to the sun and air for two days the ground soon became white, and the figures also were faded, and in eight days the crimson of the latter, which had been gradually diminishing, was no longer visible. This second experiment shews that acetited alumine is a powerful mordant for Brazil wood, but still not sufficient, finally to fix its colour.

The same piece was then dyed with a decoction of madder, and the whole came out coloured, but the figures deeper than the ground. On washing with bran and water, and exposure to sun and air, the ground became white, but the figures retained all their body and brightness of colour, and this time the dye was permanent, shewing in a very striking manner the strong affinity both of the alumine for the cotton so as to remain fixed in its fibres during three successive operations, and of the alumine for the madder colour so as to retain it permanently in spite of the washings and bleachings which entirely destroyed the dye of the ground.

Mordants not only fix colouring matter, but most commonly they in some degree alter the natural hue. Thus in the instance above-mentioned the aluminous mordant changed the dull red of madder to a bright crimson; the solutions of tin not only fix the colour of cochineal in wool, but change it from crimson to a bright scarlet: the salts of iron which are powerful mordants, always alter the colour of dyes, changing the yellow of weld to olive-brown, drab, or lead-colour according to circumstances, the red of madder to a violet brown, and, as is well known, striking a bluish-black whenever the gallic acid is present. Hence a great advantage is most ingeniously made of mixing different kinds of mordants to

produce varieties of shade; thus a mixture of the iron and aluminous mordant will produce with madder all the shades of flea-colour, purple and violet; with weld, brown and olive green, and the like, so that with no more than three or four colouring materials an almost infinite variety of dyes may be produced by a due selection and mixture of the various mordants.

On the subject of mordants, the following interesting memoir, by Messrs. Thenard and Roard, will illustrate every part of this branch of dyeing. See ANNALES DE CHIMIE.

Mordants are those substances which serve to effect a perfect combination of the colouring matter with stuffs, and that increase their beauty. Those properties are possessed by a great many saline and metallic substances; but those that possess them in the greatest degree, and which, for that reason, are preferred by all workmen, are alum, acetate of alumine, tartar, and solutions of tin.

The examination and analysis of the effects produced by these mordants, upon animal and vegetable substances, shall be the subject of our present investigation.

We shall divide the subject into four chapters, in which we will make known successively, the action of alum, the acetate of alumine, of alum and of tartar, and of the solutions of tin upon silk, wool, cotton and thread, agreeably to the methods most commonly employed in dyeing.

On Alum. The manner of using alum, which is called "alunage," (aluming) varies according to the nature of the stuffs, and to the colours that are desired. For silks, it is left to macerate for some days in the solution of alum sufficiently strong to prevent the chrystallization of the salt. Aluming wool is effected by boiling it for two hours in water, with a fourth of its weight of alum. Cotton and flax thread are alumed with a strong solution of alum in luke warm water, to which potash is often added, and in which it remains at least for 24 hours. It has hitherto been thought, that in this operation, alum was decomposed, and that alumine was combined with the stuff, the colour of which was more easily fixed, when dipped in the dyeing liquid: but the experiments which have been made, force us to reject this opinion.

Analysis of Aluming of Silk. Ninety-five grammes [*one gramme is ten deci-grammes or eighteen grains eighty-four hundredths*] of silk well cleansed, and perfectly purified, having been put into a glass vessel, for the space of 6 days, at the temperature of the atmosphere, with about 4 quarts of distilled water, and 100 grammes of pure alum, which had been previously dissolved in a complete manner. After this time, the silk being taken out of the liquid, was hung up to be entirely dry, over the alum bath, and washed several times with distilled water, to separate the part of the mordant, which had not been combined with it. The alum bath and the washings, were evaporated with much care, and they gave often, and even to the end, very transparent chrystals of alum. These first results show us, in a positive manner, the nature of the combination formed with the silk, during the aluming, and that it was at the same time very probable, that the alum had not been decomposed. We again boiled that alumed silk in a matrass, with six litres or quarts of distilled water; after having let off the boiling water, we washed it twelve times; the 72 litres or quarts arising from these 12 operations, having been evaporated, gave us again well defined chrystals of alum, which quantity added to that from the alum bath, did not differ more than two decigramme, or one four hundred and twentieth part from the 95 grammes which had been employed. If after each of these twelve washings, you try to dye silk, the colour becomes less and less deep, so that after the twelfth washing, the silk becomes incapable of being dyed. The silk being disalumed, or deprived of alum, and again alumed, acquires immediately the quality of fixing the colours as strong as before any washing. From which results, the natural explanation of the cause, why the alumed silks take colour more intensely, when they are dyed at a low temperature, than when they are plunged at once into boiling water. The reason is, that in the first case, the action of the boiling water on the mordants is so quick, that the colouring matter has not time to be fixed in it, in order to give insolubility to the combination; but in the second case, this effect cannot take place.

Analysis of Alumed Wool. After having determined the phenomena, that take place in the aluming of silk, it became necessary to continue the examination in the case of wool, and to only employ matters perfectly pure, and especially free from carbonate of lime, which is always in a pretty strong proportion. To separate it from them, we boiled them several times in a matrass, with very weak muriatic acid, but in order to extract the last portion of the acid it was necessary to use so considerable quantity of distilled water, that we were ready to abandon the experiment, which required, besides time and patience, the greatest care. The separation of the mu-

riatic acid, from the two first hecto grammes of wool, which we had purified, required 200 litres of distilled water, the temperature of 100 degrees of the centigrade thermometer, and being divided into 20 successive operations, every one lasted from seven to eight hours Calcined and treated properly, the lime and muriatic acid disappeared totally. One hundred grammes of this wool, have been alumed with the same caution that was employed in the case of silk. Afterwards it was submitted to 20 washings, at the temperature of 100 degrees, of the centigrade thermometer, in a matrass, with 6 litres of distilled water for each operation. The aluming being finished, this wool took colours the most intense, while after the last washing, it could not receive a colour from the dye, more than the same white wool, that had not received any mordant. These comparative experiments show us, that the substance which had been fixed by the aluming, and which at first had determined the colouring of the wool during the dyeing, had been removed by the water. The alum bath evaporated, gave in the state of chrystals two thirds of the quantity of alum which had been employed: we found almost entirely, the other third in the residue of the bath, chrystalizable with difficulty, and in the produce of the washing of the alumed wool. We repeated these experiments several times, and constantly with the same results; but as they did not appear to us, as sure as that on silk, on account of the difficulty of separating the animal matters, from the last part of the alum bath: we alumed the wool in the cold, as we had done the silk, persuaded, that in that case, the bath could not sensibly dissolve that matter.

We alumed in the cold, in a solution of alum of 5°, some pure wool, and we have taken out during the operation on the silk, either from the alum bath, or the washings, except about one four hundredth part, all the alum which had been used. As we were certain, that in the aluming of all these animal matters, the alum is entirely combined with them, without undergoing any decomposition, and that it then forms combinations, more or less soluble, which have a great affinity for the colouring matter.

Analysis of the Aluming of Cotton and Thread. After having extracted from a parcel of cotton, by the foregoing means, all the foreign matters combined with it, we alumed it in a luke warm bath, with a certain quantity of alum, and let it macerate therein two days. After that operation, this stuff dyed perfectly well, but treated afterwards at 100 degrees of the centigrade thermometer, in a mattress, with distilled water, it lost the property of being coloured in the dye vat. The alum bath, and the washings being evaporated, gave us the same quantity of alum, that had been used We succeeded in separating the alum from the vegetable matter, which it had dissolved by several chrystalizations. We did not wish in this operation, to wash the cotton as often as we did the silk and wool, seeing that the union of the alum with vegetable substances is so weak, that we cannot immerse during some minutes, the alumed cottons in boiling water, without depriving them of a great part of their mordant. So, for cotton stuffs, the greatest care is to be taken to dye them at a low temperature, because it is only when the colouring matter has given a degree of insolubility to that union, that it can, without being altered, support a great heat.

A parcel of thread, treated in the same manner, gave the same result.

Analysis of the Aluming common Wool. Our analysis have shown in the fullest manner, that in the aluming of animal and vegetable substances, the alum was combined with them, without any decomposition, but we thought it necessary to verify also, on the substances, in their ordinary state, the facts which they offered to us after being purified. The wools alumed with alum alone, always render the bath very muddy, and let fall when cold, a great quantity of white precipitate, as several chemists have observed. These precipitates, being well washed, have constantly furnished us sulphate of lime, saturated sulphate, and sometimes a little alumine. The bath was composed of a considerable quantity of alum, of acidulous sulphate of potash, combined with a small proportion of animal matter. We only found on the wool some alum, and a very small quantity of precipitate.

These experiments on the precipitates formed by the aluming, do not differ from those of Mr. Berthollet, but that learned chemist having neither examined the mother waters, nor the alumed wools, could not give, as he himself acknowledges, a clear explanation of the effects produced by the alum and the tartar in the operation of dyeing. These precipitates obtained by the common wool with alum, never occur in purified wool; and as those matters do not differ among themselves, except by the presence of the carbonate, it was natural in such a case, to attribute to that substance the decomposition of a part of the alum.

We ascertained ourselves in treating during many hours at the temperature of 100 degrees, in a glass vase, some solutions of alum in distilled water, with different proportions of carbonate of lime. We have acknowledged, that the alum was decomposed by the carbonate of lime; and that if you had a sufficient quantity of it, there would not remain the smallest particle of the alum salt in solution. The mother waters are the very acid sulphate of potash, and the precipitates are formed of the sulphate of lime, and the acidulous sulphate of alumine, and of potash: from which it follows, that the property possessed by ordinary wools, of forming a precipitate in the alum bath, and causing a great degree of acidity therein, proceeds really from the carbonate of lime. We obtain moreover a result precisely similar, in making with ordinary wool, 5 or 6 successive alumings with the same bath. But to come to a general solution of the question, it was necessary to ascertain the nature of the precipitate formed in the solutions of alum, by means of several alkaline and earthy substances. We have taken then, alums with base of potash, and base of ammonia, which we treated with ammonia and carbonate of potash, in such a manner, as to have in their solutions a small excess of alum. The mother waters evaporated, were very acid sulphate of ammonia, of potash and ammonia, and of potash according to the nature of the alum, and the precipitant employed. The precipitates, which were acidulous sulphate of alumine and of potash or ammonia, treated by the sulphuric acid, gave some alum, and acidulous sulphate of alumine; boiled moreover a number of times with distilled water, they were changed into alum, into sulphate of potash, and into pure alum: but more of the acid sulphate of potash, than of alum.

The solutions of alum, brought to 100 degrees of heat, on the centigrade scale, with pure alumine, were converted into very acid sulphate of potash, and acidulous sulphate of alumine and potash. After this, we could have no doubt as to the alterations produced by the common wool in the alumed baths, and upon the inconvenience of alkalies in those destined for cotton; for the addition of those matters diminishes the quantity of alum, and even increases the acidity of the bath.

"*On the aluming of animal and vegetable matters, with the acetate of alumine.*—Wool, silk, cotton, and flax, in the different states, in which these substances are employed in dyeing, have been treated with the acetate of alumine, which has completely combined with them. But as in the exposure to the air, in a temperature a little elevated, the mordant always loses a small quantity of acid, it follows that the combination formed upon the stuff is an acetate, with excess of base; for this reason, in treating it with boiling water, it is converted into an acid acetate of alumine, which is dissolved, and an alumine which cannot be extracted by washings.

"*On the action of acidulous tartrite of potash upon wool.*—Wool, well scoured, has been treated, as in the preceding experiments, with very pure creme of tartar, free from lime, and formed directly with acid of tartar and potash. This wool has been washed many times, and the last washing did not contain any more of the principles which had been combined with it. The evaporation of this bath gave us a creme of tartar pure and crystallized in the proportion of a third part of that employed, and moreover some neutral tartrite of potash. The washings were very acid; we extracted from it a small quantity of creme of tartar, and a combination, extremely acid, formed with the acid of tartar and wool. These facts might have been sufficient to explain the phenomena which take place in the aluming of wool with alum and tartar, since we know already by the experiments of Mr. Berthollet, that these two salts are not decomposed, and that we have demonstrated, that the wool is combined entirely with the alum, and that it acts upon the creme of tartar, in taking from it the tartarous acid, with which it unites in a most intimate manner: but in order to have, with respect to that, a full proof, we repeated this experiment, although long, by following the method marked out by the preceding chapters.

"Before treating wool with alum and creme of tartar, we made some experiments on the reciprocal action of those two salts. We have ascertained that water does not hold in solution, at the temperature of 12° or 14°, more than $\frac{1}{130}$ of creme of tartar, that boiling water dissolves $\frac{1}{30}$ of its weight, and that a mixture of equal parts of alum and creme of tartar, is dissolved in three-fifths of its quantity of water; that these two salts would have required to be dissolved by themselves at the same temperature. These results do not differ from those already obtained by M. Berthollet, who has demonstrated that alum has the property to augment the solubility of the creme of tartar.

"If we alum wool in the ordinary proportions, which are one-fourth of alum, and

one-sixteenth of creme of tartar of the weight of stuff, all these matters being perfectly pure, we will obtain from the alum-bath, sufficiently evaporated, some alum and creme of tartar, and a residue difficultly crystallizable, composed of the tartarite of potash and of animal matter. The washings of this wool will give some alum, and a very small quantity of creme of tartar, and a combination extremely acid, formed of much tartarous acid, of alum, and animal matter.

"These observations do away all uncertainty upon many practical facts, which hitherto offered to the dyer only some very vague calculations, and point out to him in a precise manner, the steps he ought to follow in the application of these mordants, according to the nature of the colours which he desires to obtain. In fact, in aluming with alum and tartar, we combine with wool, alum and much tartarous acid; we must only use these two salts in cases where the colour is susceptible of being augmented and rendered more lively by the acids, as is the case with cochineal, madder,* and kermes; whereas we ought not to alume, except with alum, the wool intended to be dyed with woad, wood of India, Brazil wood, of which the colours are easily altered or destroyed by acids.

"Among all the animal and vegetable substances, we chose only wool, to treat with alum, and with alum and tartar, because it is solely with that material that these mordants are employed in dyeing.

"*On the action of acids, and of some salts employed upon wool as mordants.*—Although all the attempts that have been hitherto made, to discover a substitute for alum, have not succeeded, we have nevertheless treated wool with a great variety of substances, less however to find out the most advantageous mordants, than to ascertain the action of some animal matters upon them, which are very soluble, and that possess great strength.

"We boiled wool for two hours in water, with small quantities of sulphuric, nitric, muriatic, and tartarous acids. All these specimens of wool, but principally those combined with the sulphuric acid, gave, with cochineal and madder, colours at least as deep as those obtained from stuffs alumed with alum and tartar. After that, we cannot doubt that these acids might offer in that case great advantages, if they caused the felting of the wool. But of all the mordants of which we have tried the action, there is none which has given (notwithstanding the opinion of Mr. Haussman) colours so vivid as those obtained by the intervention of the acid tartarite of alumine. The use of this salt, might be in several instances preferable to tartar and to alum, on account of the vivacity of the colours, if the price was not higher than that of the other two substances. In trying to determine with great care, all that relates to the nature and to the mode of combination of mordants with the stuffs, we have not forgotten the examination of some practical methods adopted a long time since in all the dye-shops; of which the most important is to know if the proportions of alum and tartar, the most generally employed, are in fact preferable to all others; if the time taken up by the process of aluming is sufficient to combine with the wools in a complete manner; and finally, if the method, which we believe very necessary, to leave them for some days in a cool place after the process of aluming, gives more advantageous results.

"Equal parts of mordants, or half the weight of the stuffs, do not act better than one-quarter, but in reckoning from that proportion to one-twentieth, the colours of cochineal, kermes, and madder, are weakened according to the diminution of these salts; whereas this effect operates inversely for the woad, the wood of India and of Brazil, so that in those four last substances, the colouring appears so much more deep, as the wool has received less of the mordant. Wool alumed during two, four, six hours, has given to the dye different colours; thus it is useless to prolong the aluming beyond two hours. The relative experiments, immediately after the aluming, or a very long time after, have not presented to us, among them, any difference, except only that on the wool alumed with alum alone, which on the wood gave us colours more deep, after having remained some time in a cool place: which can only be attributed to the separation of the acid sulphate of potash, which has ran out with that part of the mordant not combined with the stuffs.

"*Of the Scarlet colour.*—Scarlet is that brilliant and lively colour which is given to wool, in treating it with tartar, with cochineal, and the solution of very oxided tin. Before the discovery of this process, which is due entirely to Drebbel, they also called scarlet the colours obtained upon woollen stuffs, by kermes or cochineal, and for which they employ alum and tartar The processes for obtaining that colour, are known long since among the workmen; however they have not as yet made any theoretical researches upon the phenomena, which take place in the treatment of the solution of tin with creme

of tartar and with cochineal. Dr. Bancroft, who has experimented with much success upon dyeing, has endeavoured it is true, to show what passes in the formation of that colour, but as his opinion does not appear to us illustrated by any experiment, we ought not the less to look upon this question as being as little advanced as it was before the publication of his work. We propose to determine the chemical nature of the combination formed upon wool by the cochineal, the tartar, and the solution of tin; and to make known the result of our researches upon scarlet.

"*Examination of the precipitate formed by the solution of tin, and the acidulous tartrite of potash.*—All the matters used in our experiments were perfectly pure, and we uniformly used glass vessels and distilled water.

"Eighty grammes of acidulous tartrite of potash, dissolved in three kilogrammes, five hectogrammes of distilled water, were heated for two hours to 100° of the centigrade thermometer, with 125 grains of a solution of tin. The precipitate on being washed several times, and distilled in a retort and plunged in lime water, disengaged a very sensible quantity of carbonic acid. Proper reagents have indicated in other parts of this composition, the presence of much tin and muriatic acid. Thus the creme of tartar and solution of tin are decomposed, and give a precipitate formed of the acid of tartar, and much muriatic acid and tin. The mother-water contained tartrite of potash, acidulous tartrite, very acid muriate of tin, and a quantity of precipitate, which is held in solution by excess of muriatic acid.

"Wool, white and pure, treated with the ordinary proportions of a solution of tin, and of creme of tartar employed in the scarlet dye, having received many washings in boiling water, which have taken away all the substances combined with it; these washings, united and evaporated, yielded the same principles, which we had already obtained from the precipitate formed by the solution of tin and creme of tartar.

"We have discussed in these researches the action of cochineal, and we have ascertained that it did not make any difference from these results.

"We have acquired by these means, the certainty that this fine scarlet colour is only caused by one combination, with the wool and the colouring matter, the acid of tartar, muriatic acid, and peroxide of tin. But we would greatly mistake, if in this operation, we were to regard as nothing the influence of a bath: for wool combined with mordants that we have just noted, and passed through the bath of cochineal, never takes there the scarlet shade, and cannot take it but by the action of this very acid bath, which in making yellow loses the impression of cochineal, which gives so much brilliancy to that colour. This last experiment, and some others, which we will detail at the close of this memoir, prove to us, that the wool, as we believed, does not take the impression of yellow in that operation, by the combination which it forms with the nitric acid, which is found in excess in the solution of tin; for this wool comes out perfectly white, from all the boilings and reddenings, to which it was submitted, when colouring matter has not been employed.

"*Of the tartrites of tin, and some other metallic solutions.*—The proofs which we have just given of the formation of scarlet, appear so evident, that we should not have thought to increase the number, if the importance of this question had not induced us to give a more extended view of this work.

"We have experimented upon wool in the usual proportions for scarlet, with all the sulphates and muriats of antimony, of bismuth, of zinc, and of arsenic. Some of those solutions have given us very agreeable colours, but they differ sensibly from that which we wished to obtain.

"We have been very fortunate in our researches upon the tartrite of tin obtained from the tartrite of potash, and of soda, by the muriat of tin, very oxided. This salt dissolved in the muriatic acid, and employed in the boilings and in the reddenings destined for scarlet, have given us colours as deep and as lively as those obtained of creme of tartar and solution of tin. The tartrite of tin dissolved in an excess of its acid, produced also very good effects; however, as that way would be more costly than the ordinary process, it will be much preferable to adopt the solution of that salt in the muriatic acid. But before recommending the use of this mordant to the dyers, we propose to try it in the large way, to determine, in a very strict manner, the price and all the advantages."

Two important and distinct manufactures belong to the subject of dyeing. The one is *dyeing*, properly so called, or the art of giving an uniform colour, to an entire piece of stuff: the other is topical dyeing, or, the art of fixing various coloured patterns on an uniform ground; which, from its being chiefly and originally employed on cotton or calico, is called *Calico-printing*. The basis of each art,

as far as relates to the chemical action of the fibres of the stuff upon the different dyes and their mordants, is precisely the same, and in general, the materials employed, are nearly the same; but the manipulations and particular mode of application widely differ.

The process of dyeing in the piece consists of a few simple operations, repeated more or less often, according to circumstances; with many minute variations in the temperature, time of immersion, and the like, according to the nature of the stuff, and the colour to be given, by rules, which experience alone can teach.

The following is a short sketch of the mode of dyeing the principal colours, chiefly taken from Berthollet, Lewis, Bancroft, Hellot, and some other authorities; but, it should be added, that the variety in the processes, actually used, is almost endless; almost every manufacturer having his particular receipt, in which slight variations in the quantity, or quality of ingredients, the time, or order of application, and other minute circumstances, are found to render the colour somewhat more or less full, durable, glossy, uniform, and the like.

Of Blacks.—There are a few native vegetable juices, that produce durable *substantive* blacks; or such as can be fixed at once, on cloth, without any previous preparation. Of this kind, is the *Anacardium orientale*, a kind of nut, containing, between the inner and outer shell, a fungous substance, filled with a viscous fluid in small quantity. This juice, rubbed on linen and cotton, gives a reddish brown stain; which, by exposure to air, deepens to a full black, that is quite permanent. It is said to be used in India, for marking linen and cotton cloths, and hence, is called, the *Marking Nut.* The West India cashew nut, is of a similar nature with the East Indian *anacardium*; but the colour is not so deep. The anacardium would be highly valuable, if it could be collected in quantity, particularly for linen and cotton; but it is only used, very partially, in the countries of which it is a native.

Several other native vegetable juices, yield permanent substantive blacks; such as the American *Rhus Toxicodendron* or *Poison Ash*, and other tropical plants; but none of these are used in Europe.

The place of galls, which bear a considerable price, is frequently supplied by oak bark, oak saw-dust, sumach, the cups and husks of acorns, or other common astringents. Dr. Pennington, in his Chemical and Economical Essays, recommends this pig nut, which grows in abundance in the United States, as a substitute for galls, both for black dye, as well as for ink. Sumach is used for dyeing the black for Morocco leather.

The black, commonly given to all kinds of stuff, is that which is produced by some vegetable astringent, particularly galls, with the salts of iron; but, many circumstances must be observed, in order to produce a full and good colour. Wool takes this kind of black, with much more ease than linen or cotton, and is dyed in the following manner:

The woollen cloth is first dyed of a very deep blue, with indigo, to give a fuller body of colour. The black is then given by astringents and iron, of which the following is Hellot's elaborate and excellent process.

For every 50 lb. of cloth, take 8 lb. of logwood, and as much galls, both bruised or powdered; tie them loosely in a bag, and boil, in a moderate sized copper, for about twelve hours, with sufficient water. Put one-third of this decoction, with a pound of verdigris, into another copper, and soak the cloth in it for two hours, keeping the liquor scalding hot, but not boiling. Take out the cloth; add to the same copper, another third of the first decoction, with 4 lb. of vitriol, or sulphat of iron, and bring again to a scalding heat, and soak the cloth in it for an hour, stirring it well all the time. Then take out the cloth, and add the remaining third of the decoction, with 8 or 10 lb. of sumach; boil the whole; lower the heat with a little cold water; add a pound more of vitriol, and return the cloth for an hour longer. The cloth is then washed, and aired again, and returned to the bath for an hour; after which, it is well washed in running water, and fulled. It is, lastly, passed through a yellow bath of weld for a short time, to give a higher gloss and softness to the black. It is then washed, and dried in the usual manner.

The common blacks, however, are given in a much simpler manner; the stuff (previously dyed blue) being first soaked in a bath of galls, and boiled for two hours, and then passed through another bath of logwood and vitriol, at a scalding heat, for as much longer; after which, it is washed and fulled.

Several observations are to be made on this process.

The previous dyeing blue, is not in the least necessary to enable the cloth to take the black afterwards; but it is found to be of great service in giving body to the colour, and is never omitted in the finest blacks. The indigo blue, is the best preparation for black, being a deep, heavy dye, and assimilates well with perfect

black. When this proves too expensive for the stuff, it is sometimes prepared of a buff, or fawn colour, with walnut husks, instead of blue.

Black is never given by a single operation: that is, the stuff is first impregnated with the galls, or other astringents, either at once, or else by several processes, and afterwards passed into the vitriol bath. The colour is thus rendered much faster, than if the whole ingredients were first mixed. A certain proportion must be observed between the astringent vegetables (of which kind are the galls, logwood and sumach) and the salt of iron; for, if the former are in too great a quantity, the black is again degraded, towards a grey, rusty hue. Too long a maceration of the cloth has the same effect, as Lewis has well observed; and Berthollet remarks, that a rusty colour is given to the finest black, by being passed through a fresh bath of galls. The black colour is not entirely brought out, till after the cloth is exposed to the air; an effect, similar to the well-known deepening of the colour of pale ink, some hours after it is used.

Logwood does more than merely add to the quantity of vegetable astringent, for it contributes much to the depth of colour, and counteracts the brownish rust tinge, which galls and iron are apt to give. Where the cloth is not previously blued, logwood is particularly necessary. A very fine black is produced on blue cloth, according to Lewis, by 5 lb. of vitriol, 5 lb. of galls, and 30 lb. of logwood.

The verdigris, also, has a good effect in improving the colour; but it is not exactly known how it acts

In Hellot's process, the cloth already black, is finished by a yellow weld bath Madder has also been much used in the same way, and is supposed to give a velvet softness to the colour. The use of any of these finishing tints, is, however, much disputed, and is in a good measure, discontinued.

Wool is dyed black nearly in the same way as woollen cloth. The natural grease of the wool, is first removed by boiling in a bath of stale urine and water; after which, the wool is dyed blue and black, nearly in the way above-mentioned.

Some variety of the above processes is required, to give a black dye to silk. Raw silk, in the state in which it is spun from the cocoons, is covered with a natural kind of gum, or varnish, which gives it its beautiful orange yellow colour; and also a degree of stiffness and elasticity, which is detrimental to the manufacture, and must be first removed. This is done by boiling it in water, for four or five hours, with a fifth of its weight of fine white soap, which dissolves this gummy water. The silk loses about a fourth of its weight in this process. To dye it black, it is then boiled three or four hours, with about three-quarters of its weight of galls, and suffered to remain without boiling, for about a day, more or less, according to the kind of manufacture for which it is intended. It is then blackened in a bath of sulphat of iron, iron filings, and cherry-tree gum, with many manipulations, too numerous to be here described. Silk is seldom, if ever, previously blued, as wool is; but, sometimes a root, or fawn-coloured ground, is given by walnut husks. Silk requires many more dippings, and alternate soakings with galls and iron, than wool does, to produce a full good colour; and the quantity of galls required, differs most remarkably, five or six pounds being sufficient for a hundred pounds of wool, but upwards of fifty for the same weight of silk. Hence, the dyeing of silk, is much more expensive.

Hats are dyed with only a single bath of the mixed ingredients. The bath is made of 100 lb. of logwood, 12 lb. of gum, and 6 lb. of galls, boiled for some hours with water; after which, 6 lb. of verdigris and 10 lb. of sulphat of iron are added, and the liquor kept just of a scalding heat. Ten or twelve dozen of hats, are immersed by a proper contrivance, into the liquid, for about an hour and a half, then taken out and aired, and another set immediately immersed for the like time. Each set is dipped and aired alternately, for eight times, the bath being occasionally refreshed by more of the ingredients. The verdigris is found by experience to be essential to the beauty of the dye.

It is a much more difficult operation to fix a permanent black on linen and cotton, which will stand washing with soap, and long exposure to the air. The processes that succeed on wool, do not answer well here; the black being very liable to degenerate to a rusty brown.

Linen, or linen thread, is generally first blued with indigo, and then receives a mordant of alum; after which, it is passed through a bath of galls or logwood, or alder, and blackened with the iron solution, for which a variety of processes are given.

A fine, durable black on cotton, is of still more consequence, in the present immense trade of printed cottons, than on linen; and much pains has been taken to equal the excellent fast black, given to cotton goods in the East Indies; the process for which is not known, unless it be with the anacardium, or other native ve-

getable juices. For many years, a kind of acetite of iron, has been used very largely in England, as a substitute for the sulphat in the black dye; and also, partly as a substantive colour, by which alone many useful shades of buff, nankeen, and other dyes are given. This acetite is made by macerating refuse pieces of iron in sour beer, vinegar, elder-berries, and other substances, that afford the vegetable acids, and produce in time, a very strong uncrystallizable, high-coloured solution. Of late years too, the pyroligneous acid (obtained from the distillation of wood, in making the best charcoal for gunpowder) and the empyreumatic acid of tar, have been used very extensively in calico-printing, for similar purposes, and with very compleat success; but the precise mode of application is kept secret. It appears, that galls, or similar vegetable matter, are not required with this preparation, but the place is supplied with madder, which, with a deep iron ground, may be made to give a very dark purple-brown, hardly distinguishable from black.

Since cotton and linen, which are of vegetable origin, have naturally less affinity with colouring matter, than wool and animal matters, dyers have been in the habit in many parts of the world, of impregnating linen, and especially cotton, with many compound mordants; the united effect of which, is certainly, in many instances, to enable them to take and retain colours, with much more perfection, than any simpler process could obtain. Sometimes these mordants are animal glues, animal oils, dung, &c.; and it has been very happily conjectured, that the great advantage of these, is, in some degree, to *animalize* the vegetable fibre, as it were, and thus in point of affinity with colouring matter, to bring it more on a level with wool, silk, and the natural animal fibres. The fine turkey red of madder, fixed on cotton by a very complicated process, is a striking instance of the use of these compound mordants, as will be afterwards mentioned. The following process for dyeing linen and cotton of a fine durable black, is given by Mr. Vogler, an eminent practical artist, in which animal glue is used as a mordant, together with a solution of lead; which last seems to have a strong affinity for the materials of which the black dye is composed.

Mix, in a large bottle, a quart of soft water, with 2 or 2½ ounces of common aquafortis, and throw in from 2 to 3 ounces of litharge. Set the bottle in a warm place, frequently shaking it, till a solution is made; which, when used, should be poured off clear from the sediment. In this, dilute nitrated lead; first soak the linen or cotton thread (without heat) for ten or twelve hours, then take it out, wash it, and wring it well. Next dip the thread into a moderately strong warm glue water; wring it out, but do not wash it, and let it dry in the shade. Next, make a decoction of ¾ of an ounce of galls in a quart of water; and when they have boiled for ten minutes, throw in ¾ of an ounce of salt. Then soak the thread therein for seven or eight minutes, with a boiling heat, wash, wring and dry as before. The thread has now a dark, yellowish, grey colour. Afterwards, dissolve ¾ of an ounce of sulphat of iron, with as much salt, in a quart of clean hot water; soak the thread therein for eight or ten hours; after which, wash and dry. The colour is now black, but is much improved by the following operations. Boil ¾ of an ounce of logwood in a quart of water for ten minutes; after which, add a quarter of an ounce of starch; and, when well mixed, put in the blackened thread or stuff, and boil for 7 or 8 minutes; after which, wash it in cold water and dry. Lastly, the colour, which is much improved by the foregoing operation, is fixed by the following. Make a bath of one ounce of bruised galls, and a quart of pretty strong glue; and, when it has boiled for 10 minutes, add one ounce of vitriol of iron, and allow the whole to cool with frequent stirring. Then soak the thread for an hour in the liquor, after which, wring it out, and dry it in the shade. The dye is then compleat. Though the above process includes many operations, it does not appear needlessly complex; but, on the contrary, is very judicious, and agreeable to the long established practice of the art. Cloth of cotton or linen, may be dyed in this way, according to the author, as well as thread.

The following observations on a *new black dye*, to be applied to all kinds of linens and stuffs, by Mr. Hermbstadt, may prove useful:

The black colours, which are generally applied to linen and cotton stuffs, are composed of iron and vinegar. Their base is always oxide of iron, which is mixed with decoctions of wood of different kinds. All these colours incline either to red, or blue; and they resist but feebly the action of the air, of water, and of acids. The tincture which I have composed, and which I use daily, in dyeing all kinds of cotton, silk, or wool stuffs, to an unalterable black, embraces an intimate union of the oxide of iron, with that of copper, and the pyro-ligneous acid

Preparation of the Pyro-ligneous Acid—Take a tubulated retort, made of plate

iron, or of cast iron, which is better; place it in a furnace in such a manner, that the neck be perfectly free, and the bottom receive directly, the heat of the fire. It must be luted carefully; and there must be introduced into the retort, some chesnut wood, cut into small bits. The distillation then commences with a very moderate fire, which is progressively increased, till no more liquid passes into the receiver. The acid which is found in the receiver, mixed with a kind of oil, may be separated from it by a filter of grey paper: the wood will be reduced to charcoal in the retort.

Preparation of the Oxide of Iron—Dissolve 4 pounds of vitriol, (sulphate) of iron, very pure, in 24 pounds of rain water. Dissolve in like manner, 4 pounds of potash, in 12 pounds of filtered water. These two solutions, when well mixed, will appear at the beginning, of a deep green; but, in a little time, the surface exposed to the air, will take a dark red colour; then pour the whole on a filter of linen: the oxide which will remain after the water has passed, ought to be washed in a great deal of water, to free it from all adhering salt. Leave this oxide exposed on a plate, to the action of the atmosphere, which will reduce it to a state of red oxide.

Preparation of the Oxide of Copper—To prepare this oxide, take a pound of blue vitriol of Cyprus (sulphate of copper,) which dissolve in 12 pounds of rain water: make it boil, and mix with it a pound of water, saturated with potash, and you will obtain a green precipitate, which must be well washed after being filtered.

Preparation of the Mordant for Black.—Take three parts of the oxide of iron, and one part of the oxide of copper: triturate them in a marble mortar, and pour on them the necessary quantity of pyro-ligneous acid to dissolve them. Filter the whole, to separate the thick parts, and the mordant is made.

Application of this Mordant in dyeing Black.—Steep the stuffs intended to be dyed in this mordant, thickened at pleasure. Afterwards, proceed to the dyeing in the ordinary decoctions made with different dye-woods. The colour obtained, will be a very beautiful black, and almost unchangeable, by all chemical agents. If the black is meant to serve for printing stuffs or cloths, it is thickened very much; and by mixing it with different tinctures of dye-wood, it will form a black equally beautiful and lasting.

Process employed to obtain a liquid black—Invented by Mr. Clarke, an Englishman, and introduced into commerce; its use in marking linen in a solid and durable manner, and its application for printing cottons or stuffs:—

For these two or three years past, a black tincture has been sold for the purpose of marking linen.

A glass polisher and directions for using the tincture accompany the two bottles which contain the ingredients, and the whole is sealed up in a case.

One of the bottles contains the mordant. The other contains the ink, which is of a deep brown colour, and which must be well shaken before making use of it, because it subsides when left to rest.

The part of the linen intended to be marked, must be in the first place impregnated with the mordant, which is allowed to dry on the linen. The place which had been wetted is then rubbed with the polisher; an ordinary pen is then dipped in the ink, and the writing is performed on the linen the same as on paper. Neither soap nor any chemical preparation will destroy this writing, which, when well dried, is of a very fine black.

Having chemically analysed these two liquids, we are able to give an account of the ingredients which compose them.

Preparation of the Ink.—Dissolve in nitric acid (aquafortis) what quantity of silver you please. This solution, if the silver has been alloyed with copper, will be of a sapphire blue.

In order to separate the copper from the silver, add to the solution twelve times its weight of distilled water, or, for want of it, rain water, and suspend in it a thin plate of copper. In proportion as this plate dissolves, the silver will precipitate itself, perfectly pure, in the form of a white powder. When no more of this powder will precipitate itself the liquor should be decanted. The powder is then washed in a great quantity of water, until the water thrown upon it is no longer of a blue cast, but remains perfectly limped. The residue, *i. e.* this powder, well dried, will be silver in its purest state.

If this residue weighs one ounce, dissolve as much gum senegal and two drachms of white glue, in two ounces of distilled water. Mix this solution with three drachms of lamp-black well-calcined in a close crucible.

To manufacture this mixture properly, it ought to be triturated in a glass mortar.

This operation being finished, the solution of silver, diluted in eight times its weight of distilled water, is poured upon the above mixture; the whole is then well stirred with a spatula, and the ink is made.

Preparation of the Mordant.—Dissolve two ounces of white glue and as much

isinglass in six ounces of alcohol, and as much distilled water. This solution will be made in two days. The B. M. is made use of for the purpose; and care must be taken to stir the two kinds of glue from time to time.

After the whole is dissolved, it must be filtered through flannel, in order to keep back all its mucilaginous particles. The liquid thus filtered, and preserved in a bottle well corked, is then ready for use.

Manner in which the Ink acts.—The solution of silver in the nitric acid is nothing else than the composition of the *lapis infernalis;* and every one knows its properties in staining the skin, nails, &c. of a black colour. If the linen or stuff is first impregnated with the above mordant, which is an animal substance, the ink may be afterwards applied without spreading, and will completely dye every thread of the part to which it is applied, the mordant having previously partly animalized the fibre of the fabric.

Soap, or any other ingredient used in washing, may obliterate the lamp-black, but it never takes out the nitrate of silver; and the object proposed is therefore perfectly well attained.

Application of the Ink for printing orange Cotton and other stuffs.—We may easily conceive that this ink may be employed with advantage for printing cloths of a white, yellow, or rose ground, or any other clear colour.

The cloths or stuffs intended to be printed in this manner require no other preparation than to be dipped in a solution of parchment or isinglass; and after they are dried they must be rubbed with a glass polisher.

The ink must be thickened for this purpose with a greater quantity of gum senegal, and then applied upon the cloths or stuffs in the usual manner, by means of wooden or metal stamps.

Three or four days after this operation, the stuffs must be first washed with a great quantity of clear water, and afterwards with soap and water, which will make them appear of a finer black.

Of Grey.—Many of the varieties of grey, iron-grey, slate colour, &c. are given by processes, in general, similar to those for black, but with smaller quantities of the ingredients, and especially a shorter time of immersion. They are often finished with a weak bath of weld, cochineal, Brazil wood, and other livelier colours, to give some particular tints.

Greys may be produced in two ways—In the first, a decoction is prepared from bruised galls, and the vitriol is dissolved separately. A bath is made proportionate to the quantity of the stuff to be dyed, of the lightest shade; and, when it is so hot, that the hand will just bear it, some of the decoction of galls, and some of the solution of vitriol, are poured in. Into this, the wool or cloth, is dipped. When it has attained the shade desired, it is taken out, and more of the decoction, with more of the solution, is added to the same bath. Into this more cloth is dipped, to give it a deeper shade than the preceding. In the same manner, the operator proceeds to the deepest shades, always adding some of each of the liquors. Hellot's method, for producing grey, consists in boiling, for two hours, the proper quantity of galls, bruised and enclosed in a thin linen bag: in this bath, the cloth is to be boiled for an hour, being kept stirring, after which it is taken out: a little solution of vitriol, is then added to the same bath, and the cloth that is to have the lightest shade, is dipped in it.

It is frequently required to give greys a tint of another colour, as a nut, agate, or reddish cast. These varieties are given, by a little modification of the process before-mentioned

Silk takes all greys, except black grey, without previously aluming. The bath is composed of fustic, logwood, archil, and copperas. Some dyers form a permanent grey, by *galling* the thread, then dipping it into a very weak bath of the black cast, and then maddered. It is afterwards impregnated with a very hot solution of tartar, wrung gently, and dried. It is then dyed in a decoction of logwood. It is afterwards scoured in soap suds.

Of Blue.—The principal material for this most important colour is indigo, a singular vegetable preparation produced by the fermentation of the leaves of a small plant, the *Indigofera Tinctoria*, and one or two varieties of the same genus, cultivated abundantly in many tropical countries, particularly in Mexico and other parts of Spanish America, and of late years very largely in the British East Indies.

Many important chemical facts are connected with the preparation of this colouring matter, which, with the analysis and fuller account of the methods of solution for the purpose of dyeing will be referred to the article *Indigo*. It will be sufficient to observe in this place that indigo is brought over in the form of cubical cakes or lumps, which, (when the article is of the best kind) are of a very deep blue colour almost black in mass, very light, breaking short and easily reduced to powder; when rubbed with the nail

shewing a polished copper-coloured streak, and of a peculiar smell, which particularly shews itself when in solution.

Indigo is soluble of itself in scarcely any known menstruum except the stronger acids; water, alkalies, spirit of wine, &c. added singly, having no action on it whatever. The reason of this great insolubility appears from multiplied experiments to consist in the high degree of oxygenation in which blue indigo in its common state exists. That the blue colour depends on the action of the air is obvious from the circumstance, that in the preparation of this dye, the colour of the fermented plant is at first green, but by exposure to air it takes the deep and permanent blue, for which it is much valued. Other experiments which will be mentioned under this article make it appear that the change from green to blue is owing to this cause.

In order to render indigo soluble for the purposes of dyeing a fast colour, a complicated process is requisite. First, some substance must be added which is capable of partially deoxygenating indigo, or of reducing it to a state somewhat similar to the recent green pulp of the indigo whilst under manufacture; and next, a liquid must be added capable of dissolving the deoxygenated indigo, that it may be applied to the fibres of the stuff immersed in it. The former object is fulfilled by a great variety of substances, so different in nature, that it is hardly to be conceived that they can have any other property in common than that to which their utility is attributed, namely that of depriving indigo of its oxygen.

The additions actually employed for this purpose, or found by experiment to be capable of being so used, are other dyeing matters, such as madder or weld, vegetable mucilaginous substances, such as sugar or gum, and also many metallic *sub-oxyds*, or metals only partially combined with oxygen and capable of absorbing from the indigo that additional quantity of this principle which is requisite to complete saturation. The suboxyd of iron is chiefly used for this purpose, and is made extemporaneously by mixing lime and sulphat of iron; and as a proof of the necessity of using *sub-oxyd*, and not a perfect oxyd, it may be added, that the red perfect oxyd of the same metal has no effect whatever in bringing indigo to a soluble state. Dr. Bancroft also has found the sub-oxyd of tin equally beneficial. The sulphuret of arsenic or orpiment is also commonly used for the same purpose.

The indigo thus deoxygenated is now soluble in the alkalies or in lime-water, which are the solvents actually employed in the composition of the indigo vat.

Indigo is a *substantive* colour, or one that requires no mordant to be previously united with the stuff to be dyed. It is also one of the fastest colours known, but to render it permanent, it must be presented to the fibres of the cloth in its green deoxygenated state. Hence it is that cloth when it comes out of the indigo vat is always of a deep green, but by exposure to the air it soon changes to a fine deep blue. This change of colour of the solution of indigo from green, (or, if much alkali has been used, yellowish green) to blue, forms a very entertaining experiment in the small way. The same change is constantly going on upon the surfaces of indigo vats, which, being in contact with air, are always covered with a fine variegated green and copper-coloured scum that is perpetually passing to blue, unless stirred in and mixed with the mass below.

This constant change in the nature of the indigo, demands an equally constant attention to the state of the vat, on the part of the workmen, to keep the liquor at the proper point of oxygenation; for when the blue colour is regenerated, the indigo again partly separates from the lime or alkaline solvent, or remains only suspended in it as a fine impalpable powder, which will not adhere to cloth with any permanence. Fresh deoxydating materials also become from time to time necessary; but again, too great a quantity of this and of the lime or alkali, is equally detrimental, and so far alters the nature of the indigo, that it will no longer change to blue by air, but remains of a rusty yellowish green.

Woad, which is a fecula or dried pulp, made of the fermented leaves and stem of the *Isatis Tinctoria*, and in nature not unlike indigo, is commonly used along with indigo, in the dyeing of woollen. Woad is never employed alone, for the blue colour, which it gives, though full-bodied, and very permanent, is not sufficiently bright and glossy. In its nature and affinities for oxygen it appears considerably to resemble indigo

The bath in which wool is dyed blue, is not a copper boiler, as is the case with other dyes, but is a large wooden vat, generally sunk in the ground fitted, with a cover to protect it from the draught of external air, and to preserve the temperature more uniform. The colour is sometimes procured from indigo alone, sometimes from a mixture of indigo and woad.

The latter is prepared in the following way.

Two hundred parts of woad broken small, are first thrown into the vat, to which is then added, a hot decoction of 15 parts of weld, as much madder, and a basket of bran, all boiled in a separate vessel, with water enough to fill the wooden vat. This is allowed to remain at rest for six hours, when the whole is well stirred together, and again let to rest. A kind of fermentation is thus produced in the vat, attended with very strong acrid vapours, owing to the beginning decomposition of the woad. After a sufficient time (during which the stirring is often repeated,) four parts of lime are added, which turns the vat of a black colour, and makes the fumes still more acrid. Immediately afterwards from 5 to 15 parts of indigo (more or less according to the depth of colour to be dyed,) mixed up with water, into a cream-like fluid poured in, and the whole stirred and covered. The disoxygenation of the indigo, is effected by the action of all the vegetable matter already in the vat, and when thus altered it is dissolved by the lime. The signs of the solution of the indigo, are the rising of a blue copper-coloured and variegated scum, and the liquor beneath becoming of a bright green.

Before the cloth is put into the vat, it is wetted with clear hot water and wrung out. The time of remaining in the vat, depends on the depth of colour wanted, and on other circumstances.

It comes out green, as already mentioned, but the colour changes to blue by exposure to air. It is then thoroughly washed, to discharge all the colouring matter that is not fixed, and dried in the field.

Dr. Bancroft thinks (and with some reason,) that the weld and madder added to this vat, have little other effect than to supply vegetable matter, for the fermentation, which is to disoxygenate the indigo, and hence, that instead of these expensive ingredients, any herbs, or a greater quantity of bran, or coarse sugar, or many other cheaper materials, might be substituted.

A richer blue bath, that gives a finer and softer colour (but is more expensive on account of indigo, alone supplying the blue colour,) is made by boiling in a copper with sufficient water, nine parts of pearlash, with as much bran, and one part of madder, after which nine parts of indigo, ground up with a little water are added, and a gentle heat kept up for about forty-eight hours, stirring the whole well together, three or four times during the solution. In this case the alkali is the solvent of the indigo when deoxygenated by the bran and the madder.

In other indigo baths, the ammonia contained in stale urine, is the solvent of the colouring matter, and the deoxygenating matters are madder and tartar. The variety is endless of combinations thus afforded by the use of a vast number of vegetable matters, with lime or any of the alkalies.

Silk is dyed in a similar indigo vat with the foregoing, and without woad. For the very deep colours, however it is found necessary to prepare the silk, with a high purple from archil.

Metallic sub-oxyds and sulphurets were mentioned to be equally powerful in deoxygenating indigo, with vegetable matters, and to be employed accordingly. This chiefly takes place in preparing the indigo vats for cotton and linen. A very simple and efficacious mode of composing this kind of blue vat, is to mix together one part of indigo, two parts of sulphat of iron, and two of lime, with sufficient water in a vat, to stir them together very well, for a considerable time, and then suffer them to remain two days at rest. In this case part of the lime first decomposes the sulphat of iron, separating the sub-oxyd of iron, which then acts on the indigo, and brings it to the state of the green-yellow, or deoxygenated indigo, at which time, it becomes soluble in the remainder of the lime. This vat therefore consits of a solution of deoxygenated indigo by lime, mixed with some sulphat of lime, (arising from the decomposition above mentioned) and at the bottom is a sediment of the oxyd of iron, with any undissolved lime, or regenerated blue indigo, that may be contained. The cotton comes out of the vat green, as in the former case, and turns blue by exposure to air. It is the constant practice, after the cotton is dyed, to pass it through a cistern, containing cold water, with a small proportion of sulphuric acid. This is found to heighten the colour, and is of further use, in dissolving out any adhering lime or sulphat of lime, which would give a harshness to the stuff and impair the lustre.

Alkalies are also frequently used instead of lime in the above vat. Their effect is precisely the same as that of the lime, only being themselves, much more soluble in water than lime, they will bear a much larger proportion of indigo, and of course will form a much deeper and richer dye.

The indigo rapidly *regenerates* or recovers its oxygen (and with its blue colour)

at the surface, of all these solutions, and in so doing, it separates from the alkali or lime-water, which held it dissolved, and partly sinks to the bottom, partly remains entangled in the scum. Hence the use of the occasional stirrings, to mix the regenerated indigo, with the other materials, and again dissolve it. Frequent additions are also used, of the deoxygenating and dissolving substances to refresh the vat, when long exposed to air, and bring it back to the proper state for dyeing.

It is remarkable that the salts of copper are found by constant experience, to have a totally opposite effect on indigo, from the salts of iron, the former being observed not only to have no effect, in rendering indigo soluble, but even to prevent the operation of the sub-oxyds of iron, and to hasten the regeneration of dissolved indigo. This is supposed to be the reason, why cottons, first soaked in sulphat of copper, and then passed through a very weak indigo vat, extract at once all the colour, the copper determining the immediate separation of the indigo.

Orpiment or sulphuret of arsenic, is chiefly used in preparing the indigo solution for topical application in calico-printing. Mr. Haussman mixes for this purpose 25 gallons of water, with 10 pounds of indigo, (more or less according to its quality,) to which is added 30 lb. of good pearlash, 12 lb. of lime, and 12 lb. of orpiment. The whole is boiled for a sufficient time with stirring, and forms a very strong yellow liquid solution, which turns blue by exposure to air. For calico-printing it is thickened either with gum senegal or with starch, to the consistence of a jelly, and when strongly impressed on cotton, it forms durable blue figures. The extreme inconvenience of this, and all other solutions of indigo in lime or alkalies, is the impossibility of preventing the perpetual regeneration of the indigo, before the whole is used; and as all the colour prematurely regenerated, is readily washed away, in the after processes, it becomes extremely difficult to maintain an uniform shade of blue, through the pattern of a whole piece of cloth. The gum or paste is of further use, in retarding this premature change of the indigo.

According to Professor Pallas, cotton and silk, are dyed blue at Astracan, by a bath very similar to the simplest indigo vat for wool, the deoxygenating substance being honey, and the solvent of the indigo being soda.

The proportions are two pounds of indigo, five pounds of carbonat of soda, two pounds of lime, and one pound of clarified honey. These are put with sufficient water into large earthen jars, set in brick work over a fire, which will bear a boiling heat, and are heated with frequent stirring, till the indigo is dissolved.

Saxon Blue, is the name given to a totally different preparation of indigo, from those hitherto mentioned, and is made by digesting this colouring matter for above twenty-four hours, with a gentle heat, in about four times its weight of strong sulphuric acid. This acid (thus concentrated, which with the assistance of heat would charr and destroy most vegetable matters,) produces but little apparent alteration on indigo, but dissolves it into a fluid of an inky blackness, when undiluted, but when largely mixed with water, it produces a very beautiful transparent blue liquor, of a brighter colour, than the alkaline solutions of indigo, and capable of giving very fine dyes to cloth, silk, or cotton. The great inconvenience however, of the Saxon blue, is the extreme difficulty of rendering it a tolerably fast colour, for when applied in the common way, it is soon destroyed by washing, especially with soap, so that the indigo in the state in which it exists in this solution, appears to have but a very feeble affinity, with animal or vegetable fibre; a remarkable contrast to the habitude of the same colouring matter, when deoxygenated and dissolved in alkalies.

The colour of the Saxon blue undergoes no notable change like that of the common indigo vats, the stuffs dyed in it coming out blue and not green. The colour takes upon woollen cloth with great rapidity, so that it is very difficult to dye it uniform through a whole piece. Some scientific dyers have thought that this dye was more permanent when the solution was saturated with an alkali just short of the point at which the indigo begins to separate, for an entire saturation of the acid will precipitate the indigo nearly unchanged. Other artists have thought alum of use in this case in fixing the colour. The action of acids upon indigo will be further mentioned under the article Indigo.

Prussian Blue is so beautiful a colouring matter for painting, that many attempts have been made to fix it permanently on cloth of different kinds. Prussian blue, or prussiat of iron, is naturally a fast colour, resisting the action of light and air for any length of time, but when dissolved in any of the alkalies, or in lime-water, the blue is immediately destroyed, and a pale straw colour substituted. The solution is a triple compound of prussic acid, iron, and the alkali or lime used. If any acid

be added to the above prussiat, to the full saturation of the alkali or lime, the blue colour is restored without immediately precipitating the Prussian blue.

Two methods have been adopted of preparing this colour for dyeing, the one, by mixing it with muriatic acid, in which case it is only suspended and not dissolved; the other, by dissolving it in alkalies or lime, and saturating the solution to that point at which the blue colour is restored. The Prussian blue in either case has sufficient affinity with the fibre of cloth to unite with it rapidly and firmly.

Some have used an acetite of iron as a kind of mordant to the cloth before the application of the prussiated alkaline solution. It is necessary in all cases where this solution is used, that it be neutralized with an acid to diminish the strong affinity between the alkali and colouring matter, which without this assistance the cloth alone could not overcome.

Two capital inconveniences have hitherto been found to attend the use of this substance as a blue dye, the one the extreme difficulty of making it take at all uniformly on a moderate extent of cloth; for an immersion of a very few minutes is found sufficient to give the full effect of this colour, and hence the dye is deposited so rapidly as to be constantly wavy and uneven. The other defect is, that it is readily discharged by soap, the alkali in the soap having the same effect on the colour fixed in the fibres of cloth as it has on prussian blue in substance, so that after a very few washings, the colour becomes of a dirty yellowish brown. Stuffs dyed with this colour therefore must be washed with bran, or oatmeal, or in any other way in which no alkaline substance is employed.

A basis of other colours is often used in dyeing with prussian blue.

Very beautiful greens are produced with this colour, and the permanent yellows.

Dr. Bancroft, in his curious experiments on this colouring matter, observes, that when cotton is printed with a mixture of adjective colours, and an iron mordant *without alum*, and afterwards dyed with prussian-blue solution, the result is not a mixture of the blue with the adjective colour already applied (for example, green, where the latter is a yellow) but is simply that colour which the prussian solution would produce with the iron mordants without the adjective dye: or in other words the prussian blue appears merely to displace the first applied colour, and unite with the iron mordant. It has however the capital advantage of dyeing much more uniformly than in the common way, so that in this instance the adjective colour appears to divide and distribute the mordant more accurately than could be done without it. On the other hand, where the adjective colour is fixed with an alum mordant, the prussian blue cannot displace it, and therefore unites with it, forming an intermediate shade of colour.

We have seen therefore, that blue may be dyed with various substances; as with the blue vat with indigo, with the vat of pertel or woad, or by means of blue vitriol and logwood: That the blue vat is made in different ways; as, with ley, urine, lime water, &c. When indigo is employed, it is necessary to understand what is meant by its deoxydizement. In order to render this subject familiar, we shall subjoin the following remarks, extracted from the *London Tradesman.*

To deoxidize indigo, is to bring it back to the same colour, and the same state, with regard to the minuteness of its particles, as it appeared in immediately after its being expressed from the leaves of the indigo plant: this is termed *springing* by the dyers. When deoxidized, it passes instantly from the blue to the green state, and springs, as it were, from the bottom of the vat, and becomes equally dissipated throughout. Chevraul, a French chemist, however, has shown, that the indigo exists *in the plant*, chiefly in the state of a *white* matter, which becomes *blue* as it absorbs oxygen. What is termed *springing*, then, appears not to bring the indigo back to the state of a white matter, as it exists in the plant, but to deoxidize, or, in other words, to separate the oxygen, probably to such a degree only, as to produce the green colour. See Thomson's *Chemistry*

There are various methods practised by the calico printers and dyers to take the oxygen from indigo; the following is used by the dyers of cotton goods, whose pieces are generally from 24 to 28 yards long, and 6-4ths to 9-8ths wide. Having two vats, each 6 feet deep, 3½ wide, and 6 long, with a light frame to go so easily out and in, and two slides on the two sides to move up and down with hooks on the slides, and on each side of the frame on which they can be fastened by the two selvages at the top and bottom of the piece, (the slides are for the purpose of stretching the pieces, and are moveable, that they may be placed according to the width of the goods,) take eight pounds of good indigo well ground, boil each pound with two of potash in one gallon of water for two hours, and then put it in the vat,

which you mean to work as your dyeing vat, having previously charged it with water; add four pounds of stone lime newly slacked, to each pound of indigo, stir it up well, and put two pounds of copperas to each pound of indigo; stir it well again, let it settle 24 hours, when it ought to be fit to work. Chalk is sometimes used instead of lime, but is not by any means so good. According to the shade of blue required, add or diminish your indigo, keeping the same proportions of lime and copperas; and when you find it get weaker, add lime and copperas, with often stirring up, until you have exhausted your indigo. The other vat, which is filled with pure water, is to dip the piece with the frame, in and out as soon as it is taken from the former one, by which means the colour is rendered regular and level, that is, even and free from stains: for the liquor of the dyeing vat, when it first receives the air, fixes on the piece, and in taking it out of the vat, runs from the top selvage to the bottom one, and acquires oxygen from the air: thus the bottom selvage would, without that caution, become darker than the top; but this irregularity of colour is prevented by the water vat, as the piece is plunged into it immediately on its being taken out of the indigo vat; it washes off the colouring matter that would lie in loose particles, while, at the same time, the water gives out as much oxygen, to the indigo, as to let what has entered into the interior of the cloth remain. It is more probable, however, that the water is not decomposed, but that the oxygen is obtained from another source; namely, from atmospheric air. For dark blues, the water vat may be done without, as the marks caused by the running of the colour are not discovered; but for the light blues, it is indispensable.

There is no doubt but the cloth has an affinity for the indigo in that state, or when it came into the water the dye would wash off; but the cloth impregnated with the liquor equal to the strength of that in the vat, whenever it comes in contact with the atmosphere, these minute particles, by acquiring oxygen, become in an instant larger, and are thus detained in the thread of the cloth; in addition to this, if the cloth should be dipped into the vat again, it keeps the indigo that is on the piece, from deoxidizing, and thus retains what it has got.

Indigo is one of the best dyeing drugs we are acquainted with for the consumer, as when it is on the cloth it is neither affected by acids or alkalies in common use, whilst astringents and iron make no stains; through time, it gets lighter by washing, and air. The only method to make it as durable as can be, is to have the indigo as much deoxidized as possible, and let the cloth remain in the liquor one hour at least, so that it may penetrate well, and have the liquor so strong that the colour may be obtained with only one or two dips, because the longer the pieces are in the liquor, it penetrates the better into the interior of the thread, whilst the oftener it is dipped and receives the air, and dipped again, it lies more on the surface of the cloth in small particles, and by friction, or washing, or wear, falls off. There have been some dark blues that would rub and beat off as much colouring matter as might dye a good light blue.

It is general, after blues are taken out of the water vats to run them through a cold liquor, composed of water and sulphuric acid, so sour that it shall taste in the mouth like lemon juice; this is to take off what iron or alkali the piece may have got in the vat; it also destroys the greenish tinge, and makes it appear of a brighter blue; they are well rinsed out of this sour liquor, and washed in a little hot water, which tastes slightly of alum; this also helps the fixity of the colour.

The method of deoxidizing indigo, as practised by the calico printers, for their pencilling blue, is thus: Take 1 oz. of good indigo, ½ oz. orpiment, ½ lb. pearl-ashes, ½ lb. lime. Mix the lime and ashes together, let them settle, take off the clear ley, boil it to the strength, and quantity of caustic ley you want, then put in the indigo, boil it one hour, take it off the fire, let it cool, and then stir in the orpiment; lastly, thicken it with gum arabic, according to the purpose for which it is wanted.

Indigo thus treated, penetrates uncommonly well, and is the fastest of all blues; it is even more deoxidized than in the blue vat of the dyer; it ought to be a yellowish brown, and when exposed to the air it changes from a yellow to brown, from that to green, and then assumes a blue. This mode, however, cannot be practised but in pencilling, for were it put upon a block for printing, from the exposure of such a surface to the atmosphere as would be necessary, it would most rapidly acquire oxygen and become blue before being applied to the cloth, and then its particles being enlarged, would lay on the surface and be washed off; likewise the strength of the caustic alkali would injure the printing blocks; however that might be got over if the first could. When the printers use the block in printing blue, they print on the indigo,

finely ground, mixed with gum to make it work freely, then dry it; have ready two vats, similar to those first mentioned, each filled with water; with as much copperas in the one, and in the other as much lime, as the water in each will take up; a frame must also be in readiness, like that described above; let the piece be hooked on it, put it in the lime vat, then the copperas vat alternately, till the copperas and lime have deoxidized the indigo on the cloth so as it shall become fixed: this is what the printers call their China blue; it is rather inclined to pale blue, but very durable.

The calico printers sometimes pencil on the top of a yellow, in which case, if copperas be used instead of orpiment, it darkens the astringent.

A set of experiments on the solution of indigo, in different kinds of sulphuric acid [oil of vitriol] were made by Mr. Bucholz, in 1805, who found that the British sulphuric acid was a bad solvent, unless it had been previously boiled with sulphur; that the acid manufactured in the north of Europe dissolved it well in its natural state; but when deprived of the sulphurous acid gas, it became as inefficacious as the English. Hence it appears that the presence of this gas promoted the solution; of course the common sulphuric acid, in the state in which it is usually employed by the dyers, namely, blackened with vegetable matter, answers their purpose better than the purest.

Of Yellow.—Yellow is so common a colour for the extractive part of vegetables as to furnish a considerable number of dyes, many of which are only used extemporaneously by uncivilized nations in different parts of the world, and scarcely known beyond those parts. The yellow dyes actually employed in this country are few, and it happens unfortunately that the most beautiful are not the most permanent. All the known yellows are adjective colours, or such as require a mordant, and on the whole this is a dye easily given, but always (when on cotton and linen), liable to be impaired by the action of light and air.

Weld (*Roseda Luteola* Linn.) is a slender plant growing to the height of about three feet, and cultivated for dyeing in many parts of Europe. The plant is cut when ripe, and simply spread out to dry, after which it is tied up in bundles, and used in this state without any other preparation. It requires nearly a boiling heat to enable water to extract the colour of weld with effect, and a coction of three quarters of an hour before the whole of the colour is exhausted, during which time it is loosely tied in a bag, and kept down in the boiler by a heavy wooden frame. The decoction of weld, when concentrated, is a brownish yellow, when diluted it is more of a lemon yellow with a shade of green. The appearances which occur on the addition of acids, alkalies, &c to a decoction of weld, are treated at large by Berthollet (ii. p. 259) to which we refer the reader.

Weld is considered by most dyers as, on the whole, the yellow which unites beauty with durability in the highest degree.

Wool, and woollen cloth is dyed with weld (according to Hellot) in the following way. The wool is first cleansed in the usual manner, and then passed through a bath of about 4 parts alum and 1 of tartar to every 16 parts of wool. The quantity of tartar is determined by the greater or less brightness of colour wanted to be given. It is then dyed in the weld bath, for which about 3 or 4 parts of weld (often much less) are used to 1 part of wool. For economy, the weaker shades of colour are dyed in the same bath after the stronger are finished.

A golden yellow with more or less orange is given by a weak madder bath after the welding.

Silk is dyed of a golden yellow generally with weld alone. The stuff is first boiled in soap water, alumed and washed, then passed twice through a weld bath in which, the second time, some alkali is dissolved which gives a rich golden hue to the natural yellow of the weld. A little annotta still further deepens the colour. The solutions of tin also apply very well to silk, and with weld give a bright clear yellow.

Some advise that the silk should be soaked twenty-four hours in a solution of tin, made with four parts of spirit of nitre, one of common salt, and one of tin, and saturated with tartar; that it should be washed, and boiled half an hour, with an equal quantity of weld flowers. A fine straw colour is thus formed, which is said to resist the action of acids.

To dye cotton yellow, it is first cleansed with wood ashes and water, rinced, alumed, dried without further rincing, and then passed through a yellow bath in which the weld is somewhat more than the weight of the cotton. When the colour has sufficiently taken, the cotton is thrown into a bath of sulphat of copper, blue vitriol, and water and kept there for an hour, after which it is boiled with white soap-water, and finally washed and dried.

If a deeper jonquil-yellow is wanted,

the aluming is omitted, and, in its stead, a little verdigris is added to the weld bath, and the cotton finished with soda.

It is particularly in giving the lively green lemon yellow, that weld is preferred to all other materials. It is however expensive, considering the small proportion of colouring matter to the weight of the plant, and the dye is not extracted readily with less than a boiling heat, which in calico-printing is sometimes a great inconvenience. It is also found to degrade and interfere with madder colours more than other yellows, which is another disadvantage in printing, where patterns are first impressed with madder-colours, and the whole finished with a weld bath.

For the yellow colours, on printed cotton, the stuff is impregnated by means of engraved stamps, with the mordant described under madder, made by the mixture of sugar of lead and alum; the yellow colour, which the parts not impregnated with the acetite of alumine (formed as above) have acquired, is then discharged, by the action of bran, and exposure on the grass. The same mordant might undoubtedly be employed with success for cotton and linen to be dyed yellow. See Calico-Printing. Cotton velvet is usually dyed with the root, of a plant called cureum, or *terra merita*, a species of rush which comes from the East-Indies.

Quercitron Bark.—The bark of the American oak (the *Quercus Nigra*, Linn.) has been long used as a yellow dye in the United States, and was first introduced into England by Dr. Bancroft, from whose full and elaborate account of its properties the following general facts are extracted.

The colouring matter of this bark may be readily extracted by water only blood-warm. The infusion in hot water is rather turbid, and there separates by filtration a small quantity of yellow resin. The infusion will yield by evaporation an extract which contains the colour in a very concentrated state, but when kept for a short time does not answer for dyeing so well as the unprepared bark. The decoction of quercitron is of a yellowish brown, darkened by alkalies, and rendered lighter by acids: alum causes a very small precipitate of a deep yellow: the solutions of tin produce a very lively yellow and a copious sediment.

The quantity of colour contained in quercitron bark, is very great, compared to its weight, much more than in an equal weight of weld, to which it approaches the nearest in beauty and durability combined.

Wool may be dyed of a fast yellow with quercitron, by being first cleaned in the usual manner, boiled for about an hour, with one-sixth of its weight of alum, in sufficient water, then without rincing, transferred into a copper, containing a decoction of as much quercitron bark as there was used of alum, and turned through the boiling liquor, over the winch as usual, till the colour appears to have taken sufficiently.

After this, some chalk, in the proportion of one pound for every 100 lbs. of the cloth, is to be mixed with the dyeing liquor, and the operation continued ten minutes longer, when the process will be finished. It may be observed, that chalk or alkali, is of great service, in all yellow dyeing, whether with weld, quercitron, or any other colour, when the mordant is alum, as this addition helps to bring out and heighten the dye.

The yellow of quercitron, given in this way, is however inferior to that of weld.

The salts of tin, being powerful mordants, for almost every colouring matter, may be employed with advantage in dyeing yellow, particularly the finest colours. Dr. Bancroft, recommends the murio-sulphat of tin, (made by dissolving 14 ounces of tin, in a mixture of two pounds of strong sulphuric acid, and three pounds of the muriatic,) of which ten pound, with as much quercitron bark, are sufficient to give the highest orange yellow, to 100 lbs. of cloth. The bark is first put into the boiler, (tied up in a bag,) and boiled with water for a few minutes, after which the tin solution is added, the mixture well stirred, and the cloth, previously scoured and wetted, is then passed briskly through the liquor over a winch, for a sufficient time, which is generally no more than a quarter of an hour.

With an addition of alum a pure golden yellow, with less of the orange is produced; for the delicate green yellows Dr. B. uses the tin solution with both tartar and alum.

The method of dyeing cotton yellow with weld, has been already mentioned. A similar way, will answer with all the yellow dyes, but owing to the small affinity, which the fibres of cotton have for colouring matter, it is extremely difficult, by any means, to fix a full, equal and lasting yellow on this material. Even the salts of tin, which are so useful as mordants, to wool or silk, Dr. Bancroft observes, to have no good effect with cotton, and to be worse in every respect than alum.

On account of the superior beauty, and durability of the yellows given to cotton, in the process of calico-printing, to those

of common dyeing, Dr. Bancroft proposes, the use of the primers mordant, the acetite of alumine, in general dyeing. When used for this purpose, it is not to be thickened with gum or starch, but prepared simply by mixing one part of sugar of lead, with three of alum, and sufficient water. The cotton (and the same applies to linen,) should be first soaked for two hours, in the aluminous liquor, kept blood warm, and then dried in a stove: then soaked a second time in the mordant, dried without rincing in water, then soaked in lime-water, which tends to fix the alumine in the cloth, and neutralizes the acetous, acid. After this, (or where a very durable yellow is wanted, with a third aluming and liming,) it is fit for the yellow bath. in which 12 or 18 pounds are sufficient for 100 of the linen or cotton. A finish with a very weak solution of sulphat of copper seems to raise the colour.

Some of the further uses proposed to be made of the quercitron, by Dr. Bancroft, will be mentioned, when describing the cochineal scarlet, and calico-printing.

Old Fustic, so called in this country, (the *Bois Jaune* of the French,) is the wood of a large tree, the *Morus tinctoria*, which grows abundantly in many parts of the West Indies, and the American continent.

Fustic is of a sulphur colour, abounding in colouring matter, which is much more durable than any of the other yellow dyes, insomuch as when applied even substantively, or without a mordant, the dye is considerably durable, but still more so, when used with the same mordants, as weld, or quercitron.

The decoction of fustic in water, when strong, has a deep and somewhat dull red yellow, and by dilution becomes orange yellow. Acids produce in it only a slight precipitate, which alkalies redissolve, rendering the liquor red.

Fustic though valuable, for the durability of its colour, is seldom used for the pure yellows, as the colour which it gives is dull and muddy. It is chiefly used in compound colours, as in forming green with a Saxon-blue basis; or in producing with a mixed mordant, of alum and iron liquor, an infinite variety of drab and olive dyes, where the natural dullness of its colour is of no consequence. It is used chiefly in general dyeing, and seldom in printing. It goes much further than weld.

For use, fustic must be split or cut in chips, and inclosed in a bag, that no part of it, may fix in the stuff and tear it. We may heat fustic in the same way as weld, with only this difference, that in order to obtain the same shade, much less fustic is required; thus five or six ounces of this wood, are sufficient to give a lemon colour, to a pound of cloth; but the colours obtained from it incline more to orange, than those obtained from the weld.

Young Fustic, the *Fustet* of the French dyers, *Rhus Cotinus or Venice Sumach*, is a shrub growing in Italy and the South of France, which gives a fine greenish yellow, but without any permanence, so that it is never used alone, but only as an accessary colour, to heighten cochineal and other dyes, and give them an approach to yellow.

The common *Sumach*, gives a yellow dye with the aluminous mordant, but very pale and dull. It is therefore never employed for this purpose; but on account of the large quantity of gallic acid it contains, it is of great service in black dyes, and all the degradations of this dye.

Saw-Wort (*Sarrette*, Fr.) the *Serratula Tinctoria* of Linnæus, is a useful plant which gives a good lemon yellow to wool, when used with the aluminous mordant,

Dyer's Broom (*Genestrole*, Fr.) the *Genista Tinctoria* of Linnæus, a plant abundant in dry hilly countries, gives a tolerable yellow, which with an alum and tartar mordant, is sometimes used in the inferior woollen goods.

Avignon or French berry (*Graine d'Avignon*) is a very beautiful but remarkably fugitive yellow, which can never be used with advantage to the consumer, except where a very temporary but fine colour is wanted.

The American Golden Rod (*Solidago Canadensis*) though not commonly introduced, appears by the experiments of able dyers, to be one of the very best of the vegetable yellows, little if at all inferior to weld.

Several other vegetables have also been occasionally used for yellow dyes, but are of little importance. In fact scarcely any other substance, is actually employed for this colour than weld, fustic, and quercitron.

Of Madder Reds. The root of madder, (*Rubia Tinctorum*) is one of the most important of the colouring matters, on account of the great body and quantity of colour which it possesses, its durability when fixed by proper mordants, and the immense variety of shades of colour, which are obtained from it by various admixtures.

Some facts concerning the cultivation

of madder, will be described under that article. The general result of the analysis is, that madder naturally contains, two distinct colouring matters, one of which is of a deep blood-red, (for which alone it is valued,) and the other of a dun or yellow brown, more soluble than the former, but so intimately combined with it, as materially to deteriorate the natural beauty of the red portion.

The natural colour of madder therefore, is a dull orange red, with much body but little brightness; but by various means (some of them extremely complicated,) the art of man has been enabled to extract, and fix dies of great beauty from this ingredient.

Madder is an adjective colour, its stains being removed from all kinds of cloth, without much difficulty by washing, and exposure, unless fixed by mordants. Of these the aluminous salts are the most powerful, and most commonly employed. The salts of tin, are not used in fixing the colour, but when fixed, they render it more lively.

Wool or woollen cloth, when to be dyed with madder, is first soaked in a bath of alum and tartar, in varying proportions; but when the latter is in excess, the colour, though solid, degenerates to a cinnamon brown. The madder added to the bath of alum and tartar, must scarcely be heated more than blood-warm, otherwise the dye will become browner and deeper. At any time, however, the madder reds, on wool, are not so beautiful as those on linen or cotton, though easier given, and with more body.

The fixing a permanent, full, and beautiful madder red upon cotton, and especially linen, is, perhaps, the most difficult and complicated process in dyeing; and one on which more has been written, and more experiments and enquiries have been made, than perhaps any other part of this chemical art. The affinity of cotton, (and the same applies to linen) to madder-colour is so small, that even the aluminous mordant will not alone be sufficient to enable it to resist frequent washing, and especially the bleaching effect of the sun's rays. Hence, it is found necessary previously, to fix into the fibres of the cotton, one or more substances, capable of uniting with both the mordant, and the colouring matter, and to retain them with great force.

There are two principal kinds of madder colours known, but with a great variety of intermediate shades; one is the common red, not very brilliant, but considerably permanent, in which the substances used are chiefly, first, any vegetable substance, containing a large quantity of tan, and above all, galls; secondly, an aluminous mordant added to the galled cotton, generally with a certain portion of tartar; thirdly, the madder colouring matter; and fourthly, a finish, with an alkaline bath, which indeed is not essential to the fixity of the colour, but is found most materially to heighten and improve it, chiefly as has been supposed, by removing the brown-yellow part of the madder which always mixes more or less with the red, and degrades it. The other madder colour is a very bright, beautiful, and a most durable red, which, from having long been, and being still prepared at Adrianople, and other parts of the Levant, with a perfection scarcely imitable, is called the *Adrianople or Turkey Red*, and if the accounts of its preparation are accurate, it is the most complicated and tedious process in the whole art of dyeing.

The true Adrianople red, besides its uncommon beauty, has the property of resisting more than any other madder red, the action of soap, alkalies, alum, acids, and all other reagents. On this account, nitric acid is employed as a test to distinguish this red from any spurious imitations. If the latter is immersed in aquafortis, or common nitric acid, it soon loses colour, and in about a quarter of an hour, it is quite white; whereas, the genuine Turkey red cotton, will remain nearly an hour, without any perceptible loss of colour, and retains an orange tint to the last.

There can be no doubt too, that much of the beauty of the Levantine red, is owing to the superior quality of the madder, as will be noticed under that article; so that even with the best madder of the North of Europe, it is probable, that no accuracy in the dyeing can entirely make up, for this radical difference.

We shall not detail the *seventeen* distinct operations (given by the Abbé Mazeas) as employed in this process, but only describe the general way of proceeding.

The cotton yarn is first thoroughly cleansed by long boiling in water. The next step is to impregnate it with an *animal* substance; which, having a much stronger affinity for colouring matter than the cotton itself, forms an excellent basis or substratum, on which the dye may fix itself by the subsequent operations. The animal matter in this instance, is sheep's dung. Oil, is another intermede also used; and the effect of this, is certainly to assist in fixing the colour, and rendering it afterwards insoluble in all other substances. The oil and the dung are blended, and

both together dissolved in a ley of soda, and the cotton well mixed with it with much manual exertion.

The cotton is then steeped in olive oil, without the dung, brought to the state of a milky liquid, or an extemporaneous soap, by just sufficient soda. It is then steeped in three successive baths of soda and water, each stronger than the last, in order thoroughly, to separate all the oil that loosely adheres to the cotton; or all but what is intimately combined with it. This is necessary to make it take up the soluble part of the galls, with which it is combined in the next operation. A strong decoction of galls is then made, and the cotton is long and thoroughly steeped in it, with much wringing and pressing, after which it is stretched and dried as quickly as possible.

The cotton now may be considered as a compound of vegetable fibre, with the animal matter of dung, with oil, and with tan very intimately combined; and, it is then in the state fit to receive the proper mordant for the madder colour. This mordant is Roman alum, in which the cotton is carefully steeped for a due time, and then stretched and dried.

After this long preparation, the cotton undergoes an exact repetition of the whole process step by step, the dung bath only excepted; that is, of oiling, steeping in soda, galling, and aluming.

The whole of this labour being performed, the cotton is thoroughly dried and aired, and is then of a dun, or root colour, this hue being given by the galls. The next step is the maddering; but, in order more fully to animalize the cotton, a small quantity of sheep's blood is mixed with the water in the boiler, in which the madder is dissolved. The selection of the madder depends on the precise colour required to be given; the quantity is always twice the weight of the cotton. When this bath has got to a lukewarm heat, the hanks of cotton are steeped in it, well stretched on wooden frames, that keep the thread sufficiently asunder, to allow the dye to penetrate thoroughly and uniformly.

This steep lasts an hour, during which, the heat of the bath is slowly increasing; and, after it begins to boil, the cotton is taken off the frame, and let to lie loose in the vessel for an hour longer; the liquor being all the while kept at a boiling heat. After this, the colour of the bath being exhausted, the cotton is taken out, and washed in running water, stretched, and dried. Lastly, the cotton, now thoroughly and durably dyed, is finished by being boiled for four or five hours, in a closely covered vessel in a solution of white Marseilles soap, olive oil, and soda. This finishing brings out the colour, and much increases its richness and durability. In a word, *Turkey red* may be dyed thus: After boiling the cotton for three hours, in about an ounce of potash and fish oil, to each pound of cotton, with a sufficient quantity of water; wash it. After it is dryed, let it be immersed in fish oil for ten days. After washing it well, soak it in a solution of alum, composed of one part of alum, and forty parts of water. Agitate it in a mixture of cow dung and hot water, and again through alum water; then in a decoction of sumach or galls, in the proportion of an ounce to a pound of cotton. Immerse it now in a weak solution of glue; then wash it, and alum it.—Now madder it, with a half pound of madder, to the pound of cotton. Alum it, and again madder it, using from ¼ to ½ a lb. of madder more, to the pound of cotton. Then finish the operation, by boiling it in a weak solution of white soap. Instead of using alum, the acetite of alumine, has been recommended: this is prepared by mixing 1 lb. of alum, and 2 lbs. of sugar of lead in 1 gallon of water, separating, if you please, the white precipitate, (sulphate of lead) or removing it afterwards by washing. The process already mentioned, has been found to answer remarkably well, as will appear from the following observations of Mr. Lau. A. Washington, of Winchester, (Virginia):

"Mrs. Washington made attempt last summer, to dye cotton, to the colour generally known by the name of Turkey Red. She followed a receipt in the Domestic Encyclopædia, and succeeded beyond her expectations, in imparting to the cotton yarn, a beautiful, brilliant, red colour, possessing a permanence that was at first little expected. She had the yarn woven into a piece of fancy cloth, for her own wear, which has been very often washed, and still retains its brilliancy of colour, without any sensible diminution.

"Several persons have admired the colour, and expressed a great desire to get the receipt. As the Domestic Encyclopædia is in comparatively few hands, and the season for dyeing and making cotton cloth is approaching, I have thought it would be rendering some service to condense the receipt into familiar language, for general benefit. In the original it is very long, and a great many technical terms are used, which I have avoided as much as possible, &c."

As the process is, in some degree, modified, it may not be improper to give it in this place.

First—Make a lie of one part of good potash, dissolved in four parts of boiling water. Then slack half a part of lime in it. Next dissolve one part of powdered alum, in two parts boiling water, and while this last solution is warm, pour the lie gradually into it, stirring and mixing them close together. Then add to the above mixture, a thirty-third part of linseed oil, which, when well mixed with it, will form a rich milky substance, resembling cream. As the skeins of cotton are dipt in this mixture, it must be stirred, as the oil will rise to the top of it when it is at rest.

The above ingredients make what is chemically called, 'Alkaline solution of alumine, mixed with oil;' which, in speaking of hereafter, I shall call the *alkaline mixture.*

The quantity of the alkaline mixture to be made, must be determined by the quantity of cotton intended to be dyed. And to ascertain the respective parts of the different ingredients as named above, they must all be weighed; beginning with the water first, of which there must be enough to permit each skein of cotton to be entirely immersed in it.

Before the cotton (or flaxen thread, when that is to be dyed) is dipt into the alkaline mixture, it must be first well bleached and cleaned by washing, of every foreign, extraneous substance. Then boiled in strong lie made of potash, and dipt into the alkaline mixture whilst it is hot, and as wet as it will be, when the lie is well gotten out of it by drawing the skeins through the hands. The skeins are to be immersed into the alkaline mixture, one after another, and to be repeatedly dipt and drawn gently through the hand until they become well soaked. As each skein undergoes the above process it is to be put upon a pole, in the shade, to dry; in summer they are to be put out of doors where they are protected from the rain, and in the winter to be kept in a warm place, within doors. After remaining in that state for twenty-four hours, they must be well washed in pure running or rain water and again dried.—After which they are to be washed in a strong lie, made of good hickory ashes (or better of potash) one skein after another, and gently and equally pressed, by drawing through the hand or a pair of smooth wooden rollers, and again hung up to dry.

The madder is now to be used—after fixing upon the quantity, (which will be regulated by the deepness of the colour intended to be produced, of which more will be said presently) it must be put in as much clean rain water, as will completely and entirely cover the whole of the cotton. Then add thereto of pounded chalk, (which must by no means be omitted) a fourth of the wt. of the madder used. It must now be put over a slow fire, and kept for about three hours, at a state of heat, something less than boiling, or in such a state that hardy persons can put their hands into it without being scalded. During this part of the process, the skeins are to be frequently shifted and changed, that every part of them may imbibe the colouring matter. From this the cotton is taken and dried, and then washed in a large quantity of water to cleanse it. The finishing part of the process, called clearing, now follows, which consists in boiling the cotton for eight hours in water, containing a bag filled with bran. The water is to be kept in a brisk state of boiling the whole time, and as it evaporates, boiling water is to be added. The water ought also to be boiling, when the cotton is put into it. The deepness or intensity of the colour, in this mode of dyeing, will be regulated by the number of times the cotton is dipt into the alkaline mixture and the quantity of madder used. To give the different shades of red, the cotton may receive two three, or four immersions, and a quantity of madder equal to once, twice, three or four times the weight of the cotton. If dipt more than once, fresh alkaline mixture must be made each time, as it loses its qualities by standing. And the same process of drying, washing in water and lie, as above described, must be observed and strictly attended to after each dipping into the alkaline mixture, &c.

On the use of sheep's dung in dyeing cotton of a turkey red colour, we refer the reader to an ingenious essay by professor Vitalis, in the Journal de Physique.

The essential principles brought forward in this essay may be reduced to the following.

1. Sheep's dung used in dyeing Turkey red does not contain ammonia.

2. Ammonia has not the property of enlivening (roser) Turkey red.

3. Sheeps' dung acts only by the albumino-gelatinous matter that it contains; which serves to reduce the cotton to the nature of animal substances, and of course to dispose it to unite more solidly with colouring matters than before.

4. The dung and intestinal liquor of sheep are very useful for fixing colours in general, and particularly Turkey red.

As the subject of dyeing with madder is important, and especially that of Turkey Red, we would also recommend the

essay by J. M. Haussman, which may be seen in Tilloch's Magazine, or in the Domestic Encyclopedia; also that of J. A Chaptal on mordants in dyeing cotton red, in the Annales de Chimie, or in the Register of Arts, p. 212.

In dyeing this colour the animal matter, the oil, the soda, the galls, and the alum, appear all to have their distinct uses, and probably it would be very difficult to dispense with any of them (or substances similar to them) without injuring the perfection of the dye.

The fine imitation of this colour made at Montpellier is conducted in a manner closely following the Turkey process according to the testimony and actual experience of Chaptal.

The observations of this excellent practical chemist give many important rules with regard to the choice, and use of the materials too minute to be fully detailed in this place. Instead of sheep's dung the gastric liquor contained in the stomach of ruminating animals is employed, in each case, mixed with the oil and soda into a kind of oleo-animal soap. The oil should be of that kind which remains permanently united with caustic alkali into a uniform milky soap, without subsiding or running again into drops in any sensible degree. This kind of oil is probably that which is the freest from extractive matter, and the observations of other chemists have found that linseed oil, which contains very little extract is even better than any kind of olive oil.

It also seems necessary that in the mixture of oil and alkali, the oil should be in excess, or in greater quantity than in the proportions which constitute common soap: for the use of the alkali is chiefly to divide the oil and enable it to penetrate uniformly into the cotton, but if there were no excess of oil it is not likely that the alkali would abandon any of it to the fibres of the cotton. Soda does not appear to be essential, potash being found to answer as well.

The galling is one of the nicest operations. The cotton should be made to take the galls very uniformly, and should be dried rapidly, as the action of the air is found so far to affect the soluble matter of the galls, that if much exposed to it, the outer part of the cotton will become dark, and the remainder grey, and the subsequent colour will in consequence take unequally. Sumach is used with the galls in rather a larger proportion. The repetition of the oiling, galling, and aluming is practised at Montpellier as in Turkey. In the finishing part two operations are used. The first is, as in Turkey boiling with soda and soap, in a very high temperature. The boiler is closely fitted with a strong cover with only a very small hole for the exit of the vapour, and by the heat of the fire beneath the confined liquor is made to receive a heat certainly above that of common boiling, similar to what takes place in a digester. This brings out the colour to a very beautiful red, but it is further heightened by the final operation which was long kept secret, and which consists in passing the cotton through a mixed solution of nitro-muriat of tin and alum, at a blood heat.

Linen thread is dyed of a fine red by the same method, but a still greater number of successive operations are required, and in particular, the alkaline lies, should be much stronger.

Madder reds of extreme beauty, are prepared by the Armenian dyers settled at Astracan. The process as given by Professor Pallas is more simple than that practised at Adrianople, but agrees with it in the essential particulars. The madder is a fine sort that grows wild in several parts of Persia, and is dried and ground for use. The oil employed is procured from the entrails and refuse parts of the sturgeon, beluga, and other fish that are so abundant in the Volga. This supplies both oily and animal matter. The alkali employed is a coarse native soda, prepared by burning various salt plants in the vicinity. But the oil seems to be used without alkali, the soda being only employed in the finishing. The general process is as follows: the cotton yarn previously washed and well dried is laid in a tub, and covered with the fish oil, where it remains for the night. In the morning it is taken out and hung up in the air on poles. This alternate steeping in oil during the night and airing during the day, is continued for a week, after which the yarn is washed in the river and dried. A strong decoction is then made of pulverized sumach leaves and galls, to which, when still hot, alum is added. The galls and alum are in the proportion of 5 pound of each to every pud (40 lb.) of cotton. This compound liquor is poured on the cotton, and well worked in with the hands, and the yarn again dried. It is then fit for the maddering, in which sheep's blood is here also used along with the madder. The whole operation is finished by boiling the dyed cotton with a lie of impure soda in large clay pans with a very narrow neck, and set in brick over a fire.

place. The boiling continues for twenty-four hours.

A dye-house for giving to cotton yarn a fine red equal to the Turkey red was established at Glasgow by Mr. Papillon, the secret of which was purchased by the Commissioners for Manufactures in Scotland, and has been made public not long since. It consists of a very close imitation of the Adrianople process, as already described, but with a considerable saving in the length and number of applications. The particulars need not be here enumerated, but it may be mentioned generally that it consists of the distinct operations of boiling with soda,—steeping in a compound bath of sheep's dung, oil, soda and other ingredients—oiling without the dung—galling—aluming—dyeing with madder and blood—fixing the colour with the dung and oil steeps—and lastly brightening the dye with a finish of soap-water and soda.

Mr. Haussman in his observations upon Adrianople processes, announces a great simplification in the number of processes and an alteration in the mordants, by which he asserts that a red may be procured fully equal to that of the Levant. The mordant which he proposes is a compound solution of alumine and oil in caustic alkali, and is made in the readiest way by adding caustic alkali to a hot concentrated solution of alum, which first precipitates, then redissolves the alumine, after which a small portion of linseed oil (and probably fish oil would answer full as well if not better) is to be put in, and the whole mixed into a cream-like liquor. Cotton steeped twice (or where fine colours are wanted, thrice) in this alumino-oily soap appears to be then fit for maddering and to retain the colour in great perfection.

To give a full dead-red like that of the India handkerchiefs, Berthollet directs that the cotton should first be boiled in lime-water; then steeped in the bath of soda, oil, and gastric liquor of sheep, or other ruminating animals; washed; steeped in a mordant of acetite of alumine (made by alum and sugar of lead) and lastly maddered. In this case the finishing process is not required. The colour thus produced is a full red without lustre, and the deadness of colour appears to be owing to the lime-water.

Cotton dyed red may be brought down through all the intermediate shades to a pale orange, by steeping for a longer or shorter time in nitrat of tin. As a general rule, to give the brighter colours the cotton must be but moderately oiled and galled, steeped for a length of time and often in alkaline leys of the weaker sort, largely alumed, dyed with the best and brightest madder, and at the last long and plentifully soaped.

Such in a general way, are the processes by which the red colour of madder may be made durable on cotton and linen. The shades of degraded red producible by adding any iron solution to the aluminous mordant are endless. It may only be added that for the sake of economy the same bath may often be used with advantage, both for the fine bright reds, and for the violets, wine colour, and other darker shades, by employing for the former the madder bath when first warm and fresh, and for the latter the same bath when fully boiled, where the dun yellow part of the madder begins to prevail, and in which it can produce no material injury to the intended colour.

Of Cochineal Scarlet and Red.—Whoever casts his eyes on a piece of broad cloth dyed in the most perfect manner with the fine or cochineal scarlet, must be struck with its transcendant beauty and lustre, and acknowledge it to be one of the finest efforts of the art of dyeing.

The scarlet dyeing in general makes a distinct branch of trade, the materials being of that delicate kind as easily to be hurt by accidental admixture of other colours, and part of the apparatus being somewhat different from that of common dyeing. The boiler in which the cochineal bath is made is generally of tin or strongly tinned copper, for as a solution of tin is the mordant employed, no harm can arise from its being in contact with the same metal, but copper might be somewhat acted on in the process and the dye injured. The quality of the water is also of importance here, which should be soft and pure, for hard water tends to produce a rose colour, which however is corrected by boiling bran or starch in it.

Cochineal (the peculiar nature of which is described under that article) contains a vast quantity of colouring matter in proportion to its weight, and yields it very readily to water cold or hot. The infusion of cochineal is naturally of a fine crimson, and is entirely an adjective colour, but with a mordant it fixes on woollen and silk with great firmness, but weakly and with difficulty on linen and cotton.

Alum appears to have been the mordant first employed to fix the colour of cochineal on wool. It does not sensibly alter the natural tint, as it gives a deep and durable crimson. It even restores the crimson to cloth dyed scarlet by the compound tin mordant.

The astonishing effect of all the solutions of tin in heightening the colour of cochineal, appears to have been first discovered and put in practice by one Kuster, a German, who settled at Bow, near London, about the year 1543, whence scarlet was called the Bow dye in this country, and in England. It has been generally supposed that the change of the natural *crimson* of this drug to *scarlet* was owing simply to the effect of the nitro-muriat of tin, which is the common solution used by the dyers, but Dr. Bancroft has fully proved (as indeed is acknowledged by Berthollet in his second edition) that this is a mistake, and that the nitrat, or muriat, or nitro-muriat of tin used alone only heightens the colour of cochineal, but does not materially change its natural crimson; but that it is the addition of *tartar* to the tin solution which converts the crimson to that fiery bright scarlet for which this dye is so preeminently valuable. Now as scarlet is a colour composed of crimson and yellow, and as tartar changes the cochineal crimson to yellow, it may be inferred that the simple effect of the tartrite of tin (which salt is formed by double decomposition when the nitro-muriat of tin and tartar are mixed) is that of adding a yellow. This position Dr. Bancroft found by experiment to be accurate; for when cloth was dyed with cochineal, and the tartrite of tin singly made by dissolving this metal in the tartareous acid, the dye was a full scarlet. An equal effect was produced by substituting lemon juice or else the pure citric acid to the tartareous. Berthollet also found that on dyeing three samples of cloth, the first with nitro-muriat of tin, tartar, and cochineal, in the proportions commonly used; the second with the same ingredients but with a double proportion of tartar; and the third omitting the tartar, that the first sample was of a full scarlet, the second a scarlet more inclining to yellow, and the third a crimson.

The solution of tin usually employed by the dyers is prepared in the following way. Dilute nitric acid of the kind called *single aquafortis* is the acid used, and may be made by proper management to take up about one-eighth of its weight of tin. A small quantity of tin (previously granulated by being poured when melted into cold water, kept briskly agitated with a a bundle of rods) is put into a glass vessel, to which is added the aquafortis mixed with from one-sixteenth to one-eighth of its weight of common salt or sal ammoniac, and still further diluted with water. A strong action begins almost immediately, without artificial heat, and it is the business of the preparer to keep this action as moderate as possible, by setting the vessel in a cool place and adding only small quantities of tin at a time, in proportion as the last added quantity is dissolved. By this method the acid becomes fully saturated with oxyd of tin, whereas if the heat generated in the process is not checked, or if the acid is too strong, the greater part of the tin will remain undissolved in the form of a white oxyd. Even when well made, the solution (or *spirit* as the dyers call it) is apt to coagulate by mere keeping and to deposit the oxyd of tin, which it cannot again be made to take up. The use of the muriat of soda or ammonia is to prevent the spontaneous separation of the tin. The muriatic acid singly is a much better solvent for tin, taking up a large quantity and retaining it for any length of time, but the simple muriat of tin, and indeed of many other metals, is found to have a very corrosive effect on the fibres of wool, and even (in a less degree) on those of linen and cotton.

To preserve the muriatic acid in the solution, and at the same time to combine it with some other acid which has not such a corrosive effect on cloth, Dr. Bancroft recommends the murio-sulphuric solution of tin, as equal in efficacy to the nitro-muriatic and much cheaper. For this purpose 14 ounces of granulated tin are to be added to a mixture of two pounds of sulphuric acid of ordinary strength, with three pounds of muriatic acid. No particular precautions are required in making the solution, which will be equally permanent with or without artificial heat.

As the state of oxygenation of all metallic solutions, and particularly of those of tin, very materially affects all their chemical properties, a few observations on this subject may be mentioned after describing the process of scarlet dyeing.

Woollen cloth is generally dyed scarlet in two operations, though a single one will suffice, but in general is less convenient. To dye a hundred pounds of wool, 8 or 10 pounds of tartar are first put into the boiler with a sufficient quantity of soft water, and 6 or 8 ounces of cochineal. Immediately afterwards, 10 or 12 pounds of the nitro-muriat of tin are added, and when the mixture is ready to boil, the cloth (previously wetted) is put into the dyeing liquor and turned through it by a winch for an hour and a half, the liquor being kept boiling the whole time. The cloth is then taken out and rinsed, and is found to have acquired by this first

operation a full flesh colour. The boiler is emptied, and again filled with fresh water, and when nearly boiling, from five to six pounds of powdered cochineal (according to the depth of colour wanted) are thrown in and well stirred, after which about 10 pounds more of the solution of tin are added, and the cloth is then put in and stirred through the boiling liquor at first briskly, afterwards slowly, for half an hour. It is then washed and dried in the usual manner. The average proportion of cochineal to dye a full scarlet is an ounce to a pound of the cloth, and hence from the high price of this article the cochineal dye is one of the most (if not the most) expensive of all the processes in the whole art of dyeing.

This dye may be given apparently, with equal effect, by a single process, that is, by mixing together the whole quantity of tartar, solution of tin, and cochineal at once, and passing the cloth through the bath for a sufficient time; for the affinity between the wool, and the mordant, and the colouring matter is so strong, that this triple union takes place at once, and with great force. Or, the whole of the tin and tartar may be used in the first operation, and the whole of the cochineal in the second.

It may also be observed, that a great difference is found in the respective proportions of these ingredients, used by different dyers.

When a very bright flame-coloured scarlet is wanted, a little yellow fustic is added to the first bath, or else some turmeric is added to the cochineal in the second. This gives both a yellow ground, and mixes a portion of yellow with the scarlet. These additions are discovered by cutting the cloth; for, in this case, the inner part will be found dyed simply yellow; the reason of which is, that in the common process, the cochineal does not penetrate the inner part of the cloth, so that where these yellows are not used, this part remains white. If the scarlet has too much of an orange tint, this is corrected by afterwards boiling the cloth in hard water, or one that contains any earthy salt.

It is on account of the ease with which almost any alkaline or earthy salt counteracts the yellow part of all these colours, that scarlet cloth is always changed more or less, to a rose or crimson, by the process of fulling. Hence too, the scarlet is always given to wool, after it is manufactured, and not in the state of yarn.

After the full scarlet has been given to the cloth, the liquor still retains part of the cochineal, with a large portion of the mordant, and this is used for the lighter dyes; or with the addition of fustic, madder, and other ingredients, it is employed for a vast variety of mixed or degraded reds, orange, &c. Much technical skill seems to be required, to make the utmost advantage of these residues, which are still very valuable.

It does not exactly appear in what state of oxygenation, the common dyer's solution exists; but probably, before the colour is completely brought out, the metal is oxygenated in the highest degree. The nitric acid indeed, when used alone, if weak, and if the solution be made very slowly, and without heat, is found by Proust, to contain the sub-oxyd of tin, or this metal, in a very low state of oxygenation; for, it is only in this state that it remains soluble; and when more highly oxygenated, it totally separates from the acid in the form of a white perfect oxyd.

But, the muriat of tin on the other hand, may contain either the perfect oxyd or the sub-oxyd; the latter is the case when the solution is recently made, and has not been exposed to the air, from which it greedily attracts oxygen, but in this case, without separating from its acid solvent.

The muriat of tin, loaded with metal, by being boiled on more than it can take up, if cooled to the freezing point, gives abundance of crystals, which, however, again liquefy at a summer heat; and hence, must be kept in a cool place. Mr. Haussman dissolved one ounce of this salt, recently made in 8 pints of water; to which he added with constant stirring, an infusion of 2 ounces of cochineal, in 8 pints of water. A very deep violet coloured precipitate subsided, (a mixture of the sub-oxyd of tin with the colouring matter of the cochineal) which, however, by exposure to air, gradually turned to a fine carmine: but kept close in a bottle no such change of colour took place. If the solution of tin is exposed to air before mixture with the cochineal, the precipitate becomes carmine much more speedily, as it already contains nearly oxygen sufficient for this purpose. The carmine-coloured oxyd turns somewhat crimson, by the addition of ammonia, but returns to carmine when this alkali is again evaporated.

If a carbonated alkali is added to the muriated sub-oxyd of tin, a carbonated sub-oxyd is separated, which is very greedy of oxygen, but if added immediately to dilute nitrous, or dilute sulphuric, or acetic acid, dissolves therein with ease, and produces a nitrated, sulphated, or acetited sub-oxyd of tin. The nitrated sub-

oxyd however, shews different properties from the common dyer's solution, producing only a violet, or dull crimson, with cochineal, which afterwards heightens in colour by exposure to air.

An acetited sub-oxyd of tin is also formed, as Mr Haussman has also observed, by adding equal parts of crystallized muriat of tin, and acetited lead, with sufficient water, and decanting the clear liquor from the muriat of lead, formed by double affinity. This liquor to retain its state of sub-oxygenation, should be kept in a close-stopped vessel, and when mixed with cochineal, gives also a deep violet precipitate, which requires an exposure of some weeks before it entirely changes to red or carmine.

Mr. Haussman proposes the acetite of tin, as a mordant in topical dyeing, either to calico or any other substance, and with any suitable dyeing drug. As the acetites are much better mordants for printing, than the salts, with the three mineral acids, the acetite of tin, may, perhaps, be of use, in this species of dyeing; but, when prepared with acetited lead, there is always a danger of some lead being mixed with the solution of tin, which may materially and unexpectedly alter and degrade the colours.

Crimson is given to cloth in two ways, either directly, or by changing the scarlet dyed in the manner already described. All earthy salts, and especially alum, will change the cochineal scarlet into crimson, when boiled with it for an hour or more. Very hard water will produce the same effect without any addition. Hellot found that muriat of ammonia, with a little potash, gives almost immediately a beautiful rose colour to scarlet.

To dye cloth directly of a full crimson, the same materials are used as for scarlet, but less of the tin solution is employed, and alum is added to the bath. They are sometimes finished with litmus and potash, which add much to the lustre and depth of colour, but this finish is only superficial and extremely fugitive.

Silk is dyed crimson in the following way. It is first prepared by boiling with soap as usual, but not so compleatly, as it is rather of service to leave a shade of the natural yellow, which it is the object of the soaping to destroy. It is then alumed very strongly, and for a considerable time. The dyeing bath is made with the usual materials for scarlet, that is, solution of tin, tartar, and cochineal; but it is also found expedient first, to add some galls, to give a basis to the silk, to receive the cochineal dye. The particular management in the cochineal bath, need not be described.

The crimson is often slightly browned by passing the dyed silk through a weak bath of sulphat of iron. If an approach to flame colour is wanted, the silk is finished with fustic.

It is impossible to dye silk scarlet by the same method as that employed for woollen cloth; for, instead of this fine colour, the silk treated in this way would lose its lustre, and only take a very faint dye. It appears still to be a point hardly attained, though very desirable, to give to silk a full durable scarlet, equal to that on woollen.

Cochineal is very seldom used to cotton or linen, as no method is yet known (except as a lucrative secret to one or two individuals) of giving a good cochineal scarlet to these substances; and, in general, the effect of this dye on linen and cotton, is not so much superior to the cheaper madder and other colours, as to be at all adequate to the cost of cochineal.

Of Reds from Kermes, Coccus Polonicus, and Gum-Lac.

These three substances all give different shades of red, of at least as much durability as those of cochineal, but much less brilliance; and they are so totally disused in this country, and nearly so in Europe, that a very short notice will suffice.

The Kermes, (Coccus Ilicis) is a small insect found in many parts of Asia and southern Europe.

It gives a high red both to water and alcohol.

Wool, intended to be dyed with it, is first boiled in bran water, then alumed with alum and tartar, to which sour starch liquor is often added. In the dyeing process, nearly equal parts of kermes with the cloth are required, whereas cochineal need not be more than about one-sixteenth of the wool. The dyed cloth may be finished with soap water, which gives a crimson cast.

The dye of kermes is so durable, that tapestry 200 years old, was observed by Hellot, to have lost nothing of its depth of colour, during so long an exposure to sun and air. The kermes scarlet was anciently called in France *Ecarlate de Graine* (or sometimes Venice Scarlet.) It may be prepared in the same way, generally, as the cochineal scarlet.

The kermes red is much less lively than that of cochineal, and tends more to the colour of blood. It has the great advantage however, of resisting soap and other substances very well, so that grease spots

may be got out of kermes-dyed cloth, without any detriment. On the whole, it seems very worthy to be retained. Silk has never yet been made, to take more from it than a rusty red.

The Coccus Polonicus is a small round insect, found adhering to the roots of a species of the polygonum. It is not known to be employed in the dye-houses in England, but is used in Poland and countries where it is indigenous, and also in Turkey.

Lac or *Gum Lac* (which see) is a gummy-resinous substance somewhat resembling bees-wax, occasionally used in dyeing, though rarely, if ever, in this country. A part only of the colouring matter is soluble in water, and it gives a dull red but very durable dye, which has been used with advantage mixed with cochineal.

Of Reds and Violets from other substances.—Many of the lichens are capable of giving different shades of purple, red, violet and the like, and these colours are so far substantive that no mordant will sensibly encrease their durability, but they are all more or less fugitive, and can only be used with propriety to give a gloss or finish to articles already dyed. The substance called *turnsole*, *archil*, or *litmus*, is the best known of all the lichens, and is used pretty largely, especially in silk-dyeing. (See the articles *Lichen* and *Litmus*.)

Carthamus or *Safflower*, is another beautiful and delicate red, verging towards orange, sometimes used in dyeing, but is fugitive. It is the colouring material of the rouge used as a cosmetic.

Brazil Wood or *Fernambouc* is an article of much more importance than any of the preceding, and is employed very largely in dyeing. The natural colour of this wood is of a purple-red, and by different mordants it may be made to assume most of the shades of colour connected with red.

The great inconvenience attending the use of Brazil wood is its fugitive nature, and no method seems yet to be found which will prevent its loss of colour by considerable exposure to air, and its degradation by soap and alkalies. Hence the Brazil wood colours are sometimes called *false* dyes, being much inferior in durability to the *true* dyes given by cochineal or madder. The colour of Brazil wood require a mordant, which is usually alum with a small quantity of tartar. This both gives a certain durability to the dye and turns the natural purple to a clear red. Too much tartar gives a yellow tinge. It requires long boiling to exhaust this wood of its colouring matter. Nitro-muriat of tin is also an useful mordant, and gives much brilliance to the colour.

Silk is dyed crimson with this wood, and the colour is nearly as beautiful as the cochineal crimson, though much less durable. The silk is first prepared with white soap, then alumed, and then passed through a strong decoction of the wood. When the shade is too red it is brought to a crimson by finishing with a weak alkaline bath. When a very deep crimson is wanted, logwood decoction is mixed with that of the Brazil wood. Silk will not admit of the tin mordant with this wood any more than with cochineal; owing, as appears, to the too rapid precipitation of the colouring particles before they can properly fix themselves to the fibres of the silk.

Cotton takes the Brazil wood colour with difficulty, and this is always liable to be changed by soap.

The most permanent Brazil wood colours are those in which the natural purple-red is changed to orange or yellow by acids, but it is chiefly for the red, crimson, and purple hues that this dye would be the most valuable, if any means could be found to render them permanent.

Logwood, or *Campeachy Wood* is, like the former, a very hard heavy wood of a deep red or orange red colour, and largely employed in dyeing. The chemical properties of logwood will be described under that article.

The colour of logwood is extracted by boiling with water, and it then forms a deep violet red or purple decoction, like Brazil wood made yellow by acids and deepened by alkalies. The colour of logwood is more violet than Brazil wood, and it also contains much more gallic acid, and hence its use with iron liquor in all black dyes, as has already been mentioned. The red or purple of logwood is not permanent, but with alum and tartar it gives a fine deep violet, and is often used for this purpose. A fine blue is also given by dissolving verdigris in the decoction of this wood.

Silk is dyed violet by logwood on an alum mordant.

Of Fawn, Buff or Nankeen Colour.—Almost all vegetables contain in the bark or cortical part a colouring matter of a shade approaching either to brown or yellow with more or less of red, which has a certain and often a very strong affinity with the fibres of wool, linen and cotton, and may even frequently be fixed permanently in these substances without any mordant. A great portion of this colour-

ing matter is pure tannin, the colour of which is naturally of a light dun yellow. It is also often mixed with gallic acid, and hence these substances may be made to produce an infinite variety of shades composed of brown-yellow, and black, in different proportions, by the use of an iron mordant. Of these the commonest are walnut husks and sumach.

The outer bitter husk of the *Walnut* is well known to be green at first, but by exposure to air it turns of a deep brownish-black, so as to give the fingers a very durable brown stain. The decoction of this substance slowly evaporated forms successively a number of pellicles at the surface, which when well washed are nearly black, and in which nearly the same change seems to have taken place speedily, as occurs by long exposure in a moderate temperature. Alkalies do not sensibly alter the colour of the decoction, but acids brighten it and give a decided yellow cast. Alum gives a very small fawn coloured precipitate; sulphat of iron turns it black, and even oxyd of iron boiled in the decoction is dissolved therein and forms a black ink.

The root and bark of the walnut-tree give a decoction much resembling the fruit-husk.

The colouring part of this substance has a strong affinity to wool, uniting with it nearly as strongly without, as with mordants, and giving it a very fast buff or fawn colour; but alum encreases the density of the dye and makes it somewhat lighter in colour.

Walnut husk forms an excellent dye for wool, both by itself and as a basis for other colours. The husks will keep for more than a year in tubs covered with water.

Sumach is a very extensively useful article of dyeing, both for all the fawn and buff colours, and with an iron mordant, for various shades of grey to black. It requires a mordant to fix it on stuffs, but then is very durable. With alum it gives a greenish yellow, with a mixture of acetite of alumine and iron liquors it gives a grey, and with iron liquor alone, a black.

A good bright, and durable nankeen colour is given to cotton by iron liquor, the cotton, being previously prepared with dung and alkali, nearly as in the first part of the Turkey process. This method of nankeen dyeing, as given by Mr. Brewer, consists of eight operations, the first, second and third of which are to give the cotton yarn a preparation in a bath of sheep's dung and soap; the fourth a bath of pearl ash; the fifth is the dyeing with iron liquor; the sixth a pearl-ash bath; the seventh a souring with dilute sulphuric acid, and the eighth, a finish with soap. The iron liquor is chiefly the aceto-tartrite, or that which the calico-printers mostly prepare by dissolving iron in an acid made of any fermented materials, or of pyroligneous acid, or alder bark and buds, or many other vegetable matters, that either contain a naked vegetable acid, or are able to produce one by fermentation. The cotton is first soaked in this acid iron-liquor, after which it is supersaturated with pearlash, so that probably a solution of oxyd of iron in carbonated alkali is formed, which finishes the dye, and gives it durability. The use of the sulphuric acid is to dissolve out all the iron that only loosely adheres to the stuff, which being chiefly the red oxyd, the colour becomes clearer, and brighter, by the loss.

Of Green. Though nature abounds with this colour, it is rather singular, that no vegetable has yet been discovered capable of giving to cloth of any kind, a green of any tolerable permanence. This dye is therefore always a compound colour formed in dye-vats, either by putting a yellow on a blue ground, (which is the commonest) or a blue on the yellow ground, or by first mixing the blue and yellow materials, and dyeing with these, as with a simple colour.

Much nicety in the practical part of dyeing, is shewn in the proper raising and fixing of this colour, and many processes of particular excellence are carefully confined within the walls of different manufactories. The general methods however are simple, and well known.

The common and most permanent green on woollen cloth, is given in the following way. The cloth, previously dyed blue, in the indigo vat, (with more or less body of colour, according to the body of green required,) is first scoured, then dyed in a bath of weld, or any other yellow dye, with alum and tartar, almost exactly in the way followed for the simple yellows, but with a greater quantity of the yellow materials, than would be required for the yellow alone of equal body. Very deep greens have sometimes a slight brown, or kind of burnish given to them by adding to the bath a small quantity of logwood and sulphat of iron. For silk the process is reversed, being first strongly alumed, then dyed yellow with weld, and afterwards finished in the indigo vat. It is much more difficult to fix the colour evenly on silk than on wool, for the silk when strongly alumed, takes the dye so rapidly that it is apt without great care, to become wavy or spotted.

Another kind of green dye, more bright and beautiful than the last, but not quite so permanent, is the *Saxon Green*, so called, from the blue part being given by the Saxon blue, or sulphat of indigo. This colour may be dyed by first giving a ground of Saxon blue, then aluming, and then passing the cloth through a yellow bath. Fustic is commonly preferred as the yellow material,as being less altered by the adhering acid of the sulphat of indigo, than weld or the other yellows. To correct the effect of this acid, and enable quercitron to equal the fustic in this respect, (whilst its natural colour much excels it,) Dr. Bancroft advises, after the cloth has received the blue, to mix chalk with the alum mordant, to neutralize the adhering acid, before the yellow is given.

The Saxon green may also be given in a single bath: for which purpose the cloth is first alumed and well rinced; then a strong decoctionof fustic is made,to which, when cooled to a blood heat, is added the sulphat of indigo, and the cloth dyed therein, with the usual precautions. Beautiful *Saxon* greens may be dyed in a still more expeditious way, according to Dr. Bancroft, by using the compound alum and tin mordant. The process he advises, is the following. Put into the boiler 6 or 8lbs. of quercitron bark to every 100lbs. of cloth, boil with sufficient water, then add 6 lbs. of the *murio-sulphat* of tin (in preference to the nitro-muriat,) and 4lbs. of alum: when these have boiled five or six minutes, lower the heat with cold water to blood warm, after which add as much sulphat of indigo, as may be thought necessary, for the intended depth of colour, and then dye the cloth in this bath with proper care.

Silk, cotton and linen, are dyed green, in the same general way, but with considerable variation in the detail of the different processes, and the same difficulties, that attend the fixing a single colour on these substances, apply to the compound colour.

The most beautiful green hitherto known, and one that resists the action of light and air, perfectly well, is given by the combination of Prussian blue and yellow; but like the simple blue from this colouring matter it is destroyed by soap and alkalies. It is given to cotton by first dyeing it olive with weld, or any other yellow dye, and a compound mordant of alum and iron, and then raising the green by prussiat of potash, in the manner described under the Prussian blue colours. In this process, as Berthollet observes, there seems to be a mutual distribution of the mordants and colours, the Prussian colour taking the iron, and becoming blue, whilst the alum and weld, remaining in the olive, form a fast yellow, and unite with the blue into a fine green.

The only simple green commonly used, is that of the carbonated oxyd of copper, precipitated from verdigris by an alkali. A solution of verdigris is made in vinegar, and a few hours before dyeing, a solution of as much pearl-ash as verdigris is added to it, the mixture is heated, and the cotton previously alumed, is passed through this bath. The colour thus given is a soft apple-green.

Of other Compound Colours. By the mixture of red and blue in different proportions, violets, purples, lilacs, and vast numbers of other agreeable dyes are formed, but of which it would be tedious to attempt an imperfect detail. In like manner the coquelicots, brick-colours, chesnuts, cinnamons, &c. are formed from the intermixture of red and yellow. It may be added, that in cotton dyeing, advantage has been taken by Chaptal, of the difficulty, with which cotton strongly alumed and oiled (as for the Turkey red,) imbibes watery liquids, to give a singular variety of shade in the same piece, according to the direction in which it is seen, and which gives the effect of a number of small irregular streaks over the surface. If cotton previously oiled, alumed and galled, be only slightly passed through a bath, containing sulphat of iron, the nap of the cloth alone becomes entirely black, and the thread grey: if this be afterwards maddered, the thread becomes red and the nap violet, which produces an agreeable changeableness of colour, as seen in different lights.

Having thus given a general view of dyeing operations, with the kind, use, and application of mordants, and some account of native dyes, we shall conclude by observing, that more extensive information on the theory and practice of dyeing, may be found in the works of Berthollet, Bancroft, and Hellot.

Dyeing of Hats. The dyeing of hats being similar to the dyeing of cloth or wool, for information on this head, we refer the reader to the article Dyeing.

Dyeing of Leather. Leather is dyed of various colours, for different purposes. The colours used are those already mentioned under Dyeing.

Dyeing, or staining of paper, wood, bone, marble, &c. is formed with different colouring matters. The article being first prepared, if necessary, is either immersed in the dye, or the dye applied, as circum-

stances require. For the preparation of the colour, see DYEING. The following processes for staining wood, &c. may, however, be useful.

To stain Wood Yellow. Take any wood, and brush it over several times with the tincture of turmeric root, made by putting an ounce of turmeric, ground to powder, to a pint of spirit, and after they have stood for some days, straining off the tincture. If the yellow colour be desired to have a reddish cast, a little dragon's blood must be added.

A cheaper, but less strong and bright yellow, is by the tincture of French berries made boiling hot.

Wood may also be stained yellow by means of aqua fortis, which will sometimes produce a very beautiful yellow colour, but at other times a browner. Care must be taken, however, that the aqua fortis be not too strong, otherwise a blackish colour will be the result.

To stain Wood Red. For a bright red stain for wood, make a strong infusion of Brazil wood in stale urine, or water impregnated with pearl-ashes, in the proportion of an ounce to a gallon; to a gallon of either of which, the proportion of Brazil wood must be a pound; which being put to them, they must stand together for two or three days, often stirring the mixture. With this infusion strained, and made boiling hot, brush over the wood, to be stained, till it appear strongly coloured; then, while yet wet, brush it over with alum water, made in the proportion of two ounces of alum, to a quart of water.

For a less bright red, dissolve an ounce of dragon's blood in a pint of spirits of wine, and brush over the wood with the tincture, till the stain appears to be as strong as is desired; but this is, in fact, rather lacquering than staining.

For a pink or rose red, add to a gallon of the above infusion of Brazil wood, two additional ounces of the pearl-ashes, and use it as was before directed: but it is necessary, in this case, to brush the wood over with the alum water. By increasing the proportion of pearl-ashes, the red may be rendered yet paler; but it is proper, when more than this quantity is added, to make the alum water stronger.

To stain Wood Blue. Wood may be stained blue, by means either of copper or indigo.

The method of staining blue with copper is as follows: Make a solution of copper in aqua fortis, and brush it while hot several times over the wood; then make a solution of pearl-ashes, in the proportion of two ounces to a pint of water, and brush it hot over the wood, stained with the solution of copper, till it be of a perfectly blue colour.

To stain Wood Green. Dissolve verdigris in vinegar, or crystals of verdigris in water, and with the hot solution, brush over the wood, till it be duly stained.

To stain Wood Purple. Brush the wood to be stained several times, with a strong decoction of logwood and Brazil, made in the proportion of one pound of the logwood, and a quarter of a pound of the Brazil, to a gallon of water, and boiled for an hour or more. When the wood has been brushed over till there be a sufficient body of colour, let it dry, and then be slightly passed over by a solution of one drachm of pearl-ash in a quart of water. This solution must be carefully used, as it will gradually change the colour from a brown red, which it will be originally found to be, to a dark blue purple, and therefore its effect must be restrained to the due point for producing the colour desired.

To stain Wood Mahogany Colour.—The substances used for staining mahogany colour are madder, Brazil wood, and logwood; each of which produce reddish brown stains, and they must be mixed together in such proportions as will produce the tint required.

To stain Wood Black. Brush the wood several times over, with a hot decoction of logwood. Then having prepared an infusion of galls, by putting a quarter of a pound of powdered galls to two quarts of water, and setting them in the sunshine, or in any other gentle heat, for three or four days, brush the wood over three or four times with it, and it will be of a beautiful black. It may be polished with a hard brush, and shoemakers black wax.

The following observations and experiments on staining Wood, by Professor Beckmann, may prove useful.

The oldest inlaid works now extant, are preserved in Italy; and the most highly esteemed of these are those made by John, of Verona, a monk, and cotemporary of Raphael, who was born in 1470, and died in 1537. He was invited to Rome, by pope Julius II, in order that he might add to the splendour and magnificence of the Vatican; and he left behind him many specimens of his art at Sienna, Naples, and other Italian cities. The works of this artist, on account of the variety and beauty of the stained pieces of wood employed in them, are still celebrated among connoisseurs, and preferred to all new works of the like kind. It is, however, to be lamented, that the processes used by

John of Verona, are at present altogether unknown, though the wood he employed, was chiefly of European growth. Veneered or inlaid works are now so much in vogue, that there are few houses in which some of the furniture is not ornamented in this manner; and the sums of money expended every year for different kinds of foreign wood, necessary to supply this luxury, is very considerable. These woods are imported chiefly from India, by the English, Dutch and French; and some of them are of more value than the best copper, the filings of which might be employed to make imitations of them. That narrow district alone on the Rhine, between Darmstadt and Heidelberg, receives annually, for walnut tree wood, the sum of ten thousand florins. Since mahogany furniture, however, began to be used, our cabinet makers have made scarcely any thing else than common works, because we are accustomed to purchase from the English, says the professor, not only the materials, but also the works themselves; so that the time may come, when no workmen of this kind will be found in Germany: on that account, it is well worth the trouble to make experiments on the staining of wood, in order to render them equal, if not to all foreign woods, at least to some of them, since many things can be coloured in that manner, which are harder and more compact than wood. The labours of Dufay in this respect, are well known; and it appears by some papers of his among the Memoirs of the Academy of Sciences, that rock crystal, when exposed to the vapour of arsenic and antimony, assumes a red colour. Count de Borch's description of the method of staining marble in Italy, may also be mentioned; and the process by means of the smoak of oak chips, which is employed by the Dutch for colouring their tiles and earthen ware. Canes are prepared for use in India, by dipping them in quicklime. That hard compact wood brought from America, and particularly Guiana; which, on account of its variegated and spotted appearance, is called *Bois de Lettres*; and which Aublet, who gives it the name of *Piratinera Guianensis*, much admired, has its whole surface stained by the Indians, with the blackest and most durable colours. As the art of staining wood, seems at present, to be nearly lost, the following experiments may be of some utility to artists:

1. *By Means of Oils and Acids.*—Experiment 1.—A square piece of plane-tree wood, a line in thickness, was put into pounded dragon's blood from the Canaries, mixed with oil of turpentine, and placed over the fire in a glass vessel. The wood slowly assumed the colour, even before the spirit was volatilized. After more than an hour, the vessel was taken from the fire, and suffered to stand the whole night, when the wood appeared of a mahogany colour, not merely on the surface, but also in the interior parts. The denser fibres were somewhat less coloured, but this, instead of injuring the beauty of the wood, rather added to it. The red dye can be made stronger or weaker, by taking a greater or less quantity of dragon's blood, and by a greater or less degree of digestion and boiling. The wood of the plane-tree was chosen for this purpose, because it can be easily sawn and polished; because it has a white colour; is neither too hard, nor too soft; because it neither contracts, nor warps; has beautiful white spots, with veins, that cross each other; and because artists who make inlaid work, have long attempted to colour it by staining. The wood, when stained, can very easily be freed from the dragon's blood adhering to it, by means of rectified spirit of wine. The spirit of turpentine makes the wood more compact, and renders it more susceptible of a fine polish.

2. Gamboge, dissolved in spirit of turpentine, gave to the whole surface of a small piece of wood, a most beautiful shining, golden yellow colour. The fibres and veins, on the other hand, had assumed a colour, inclining a little to red. A piece of the wood of the pear tree, assumed a darker colour, somewhat approaching to green, and which, in part, was nearly an olive colour. Different colours may therefore be obtained by employing different kinds of wood.

3. One part of dragon's blood, two parts of gamboge, with spirit of turpentine, gave to the wood of the plane tree, or beech, according to the mixture of the colours and the nature of the wood, a remarkable variation of dyes. A bit of beech wood seemed always to assume a blackish yellow colour; and was thoroughly stained, when moderate heat was kept up for a sufficient length of time.

4. Distilled verdigris, (crystallized acetite of copper) could not easily be used in the above manner, as its colour is too much changed by oil and fire, as is known to those who employ it as a pigment. The olive colour also, does not penetrate to the interior part of the wood

2. *By means of Spirit of Wine.*—Experiment 1.—When dragon's blood and gamboge were merely dissolved in spirit of wine, the extract was not sufficiently strong, and the dye was of no use. The

process, however, succeeds when the spirit of wine has been long boiled, over a slow fire, till it is almost evaporated. The piece of wood appears then of a dark red colour, which is improved if the wood be washed in pure spirit of wine. But the colour is never so bright as that produced by means of an oil.

2. Gamboge with spirit of wine gave to wood in this manner a yellow, and gamboge and dragon's blood a yellowish red colour.

3. *Experiment with Wax.*—Whitewood boiled in spirit of wine, to which, when it began to boil, wax was added, could not be made to assume the green or the red dye, even in its small cross veins, which were exceedingly porous.

4. *Experiments with dissolved Salts and Metals.*—The following experiments with these substances, which have already been described by Macquer, seemed to be most successful.

Experiment 1.—A solution of common alum (sulphate of alumine) penetrates exceedingly well into wood which has been digested in it; so that hopes may be entertained of something being effected by it, as the white colour of every kind of wood becomes whiter by solutions of saline substances: this may be of great use to artists.

2. Wood soaked in a solution of gold assumed a red colour, but the inner part was only of a yellowish red.

3. Distilled verdigris dissolved in vinegar stained wood green, but the colour could never be brought to a grass green.

4. Wood which has lain a long time under water becomes black, as experience shews, and looks as if charred. It however, loses none of its toughness or compactness; and many trees dug up in Holland from the turf earth are employed there for ship-building. The effect of the sulphuric acid on wood gave occasion to the following experiment. Pieces of different kinds of wood, of considerable thickness, were placed in the sulphurous acid. In half an hour the whole surface of them was covered with a yellowish scurf, and the wood itself had the appearance of being charred. When washed in water, and exposed some hours to the open air, it was observed that the black colour had penetrated still farther, that the interior part only retained the natural colour, and that the wood was exceedingly close and compact. After this wood had been several times rubbed over with the oil or spirit of turpentine, it became harder and firmer, so that it could receive the highest polish; by which means the colour was rendered more agreeable. This process may be readily employed by artists, as it is easy, and does not require much expense.

5. Another black dye for staining wood, which succeeds extremely well, and may lead to other useful experiments, is that formed with liver of sulphur, (sulphuret of potash) and metallic solutions. As the sulphurized hydrogen gas is so subtle that it penetrates the closest bodies, it might readily be conjectured that it would easily give a black colour to wood, if the latter could any how be made to imbibe it with a metallic solution. Pieces of different kinds of wood were placed, for several days successively, in a solution of acetite of lead, and a solution of silver, copper, iron, and other metals; after which a solution of arsenical liver of sulphur was prepared in the following manner: One part of the arsenical liver of sulphur was mixed with two parts of clear quicklime, in a porcelain vessel, over which was poured six or eight parts of boiling water. The solution was then poured off, and the wood which had been impregnated with the above metallic solutions being placed in it and suffered to remain several days, the vessel being closely shut, it assumed a black colour. The solution of acetite of lead produced the greatest effect; that of silver next, and those of the other metals least of all. Spotted wood, and particularly that of the plane, beech, and pear tree, assumed the best colour. It is therefore beyond all doubt that porous wood, such as that of the lime, the elder, &c. could be stained much easier. Though the arsenical liver of sulphur from lime may appear superfluous, as the common, which is prepared from alkaline salts and sulphur, can produce the same effect, the above process however is that which ought to be recommended. This method of staining may be considered as the best, because it impregnates the wood with metallic particles, gives it a hardness susceptible of a fine polish, and secures it from worms. The vessel employed for this purpose must be either of porcelain, stone ware, or glass.

We shall now offer some remarks on the *staining of satin.*

This is an art which many of the fair sex take great delight in. The mode of preparing the colours is similar to the former: the following processes, however, may be noticed.

For Red.—Take the chips of the best Brazil-wood, and infuse them in good wine vinegar, for six or eight hours; then adding some beer that is clear, boil it in a glazed pipkin, over a gentle fire, with some alum and gum-arabic; when the

colour is found, take it off the fire, and filter it through a cloth, putting it up, when cool, into glass phials, for use.

For a Crimson. Mix carmine with gum water, in which dissolve some white sugar-candy; the shade may be made light or deep. We may likewise boil cochineal, having first beat it in a mortar to a fine powder, and mix it with alum, and creme of tartar.

For Purple. Take fresh chips of logwood, and infuse them in clean water, with some alum; after it has stood for two or three days, add to it some gum-arabic, and it is fit for use.

For Light Blue. Take litmus blue, and boil it with some alum, quick-lime, and pearl-ash, in clean water, and a pleasant blue to paint with on satin will be formed.

For a Deep Blue. Grind Prussian blue, to shade the litmus blue, tempering it with gum-water and sugar-candy.

For Green. Boil verdigris, with vinegar and salt; or only mix the verdigris, with vinegar in a phial, and set it to digest in the sun. If it is to be of a grass-green, add to it some yellow.

For Yellow. Infuse French berries in clean water, with some alum: after it has stood for a week, pour off the colour, and dissolving therein a little gum-arabic, it will be fit for use.

Of Staining or Marbling Paper. The paper must first be prepared, that it may more easily retain the colour. This preparation is performed by wetting the paper with a sponge dipped in alum water, then letting it dry. When the sheets have been thus prepared, have a pan full of water, and, with a large and long-handled painting-brush, take of one colour, and shake it in the water; take of another and do the same, and so on till you have taken of all the colours you intend to have on your paper, and which you are supposed to have there already by you. Each of these colours fall to the bottom of the water; but take, with a similar brush as the first, a mixture of bullock's gall, and of a solution of soap and water, then shake on the water, all over its surface, and you will soon see all the colours rising up again, and swimming on the top of the water, each separately as you first put them. Then lay the sheet of paper on it, give it a turn on one side or the other, as you like, and take it up again; wash, and set it to dry, then burnish it, and it is done.

We may observe, however, that this mode of producing marbled paper, will not completely answer; but in order to render the colours variegated, it is of importance to separate the different colouring fluids, which is done in this city by means of the spirits of turpentine. This is added to water, after the colours are put in that fluid.

E.

EARTHS. Chemists have sometimes in a gross and inaccurate way called those substances earths, which remain after the volatile products of distillation have arisen, and which are not soluble in water. This is not however sufficiently exact, though it is difficult to exhibit a good positive definition. Earths, are bodies simple with respect to the powers of chemical analysis, if we except the opinion of Davy, brittle, incombustible, infusible by the heat of furnaces, and destitute of that opake brilliancy, which characterizes metals.

We are at present acquainted with nine distinct substances, that are classed as earths: viz. Alumine or the pure earth of clay, barytes or heavy earth, glucine, lime or calcareous earth, magnesia, silex or flinty earth, strontian, yttria and zircon.

Which we shall here describe in this order, after some general remarks. The agustine earth, which Trommsdorf imagined he had discovered in the Saxon beryl, Vauquelin has shown, to be phosphat of lime: and the ochroit, which Klaproth supposed he had found, in the tungsten of Bastnas, appears to be a metal. As four of these earths, barytes, lime, magnesia, and strontian, have some affinity to alkalies, certain chemists have proposed, to class them as such, while

others distinguish them by the term alkaline earths. See ALKALIES.

The attention of the chemical world was once strongly excited by some experiments of Messrs. Ruprecht and Tondi, who affirmed, that they had reduced alumine, lime, barytes, and magnesia to the metallic state, by strongly heating them with charcoal. But however probable it may be from analogy, that such reductions may be within the limits of possibility, it is now universally admitted, that the metal obtained in these experiments consisted of iron from the crucibles used.

In some systems a distinction is made between earths and stones; but this is of no utility in the chemical inquiry respecting their component parts and properties. A stone is nothing more than a hard earthy mass, and an earth in powder is an aggregate of very minute stones.

Earths appear to have an affinity for each other in the humid way, which has not yet however been sufficiently examined. The affinity of alumine for magnesia is the most powerful. It has also an affinity for silex and lime. Scheele was the first who observed this; and Chenevix and Darracq have made further experiments on the subject. So has Guyton Morveau; but Mr. Chenevix observes, that he was led into errors probably by using earths, precipitated from sulphuric acid, of which they still retained a little.

The combination of earths, with acids, forms a class of salts, called earthy salts, which are an important class of bodies.

1. *Alumine, or the pure Earth of Clay.*—The principal natural specimens of this earth are, clays, properly so called, marls, boles, slates or schistus, and mica. In none of these, except the flag stone, does the alumine amount to so much as half their weight, though their predominating qualities appear to depend upon it. A fossil has been found in Devonshire, England, however, containing 70 per cent of alumine. The most obvious characters of this earth are, an adhesion to the tongue, or to any wet and soft body, in the more solid specimens; and a remarkable tenacity, ductility, or kneadability serve to distinguish moistened clays in a very eminent degree. It is soluble in acids; but alkalies act much less upon it, either in the dry or moist way, than they do on silex. Alum is a combination of this earth with sulphuric acid. If the concrete volatile alkali be added to a solution of pure alum, the alkali and acid unite, while the alumine falls to the bottom, united only with a small quantity of carbonic acid. The fluid must be abstracted by decantation, and the precipitate washed with distilled water, and dried. If we would have it very pure, alum may be dissolved in four times its weight of boiling water, and precipitated by liquid ammonia. As this method is, however, tedious, a more ready way is to procure it from such of the natural clays as contain only silex and alumine, by solution in muriatic acid, and precipitation by ammonia.

Alumine has a considerable affinity for metallic oxides, particularly that of iron; for vegetable or animal colouring matter; and for the extractive matter of vegetables: hence its uses as a mordant in dyeing, and as the bases of the pigments termed lakes.

Clays may be easily diffused and suspended in water, but are not soluble in any sensible degree. The sudden application of strong heat hardens their external parts, which afterwards burst by the explosion of the moisture within. By a more gradual heat pure clay contracts very much, becomes hard, and full of cracks or fissures. The presence of siliceous earth in common clays, where it usually constitutes above half the weight, renders the contraction more uniform throughout, and prevents the cracks; probably in no other way than by rendering them more numerous, and too small to be perceived. When thus baked, it constitutes all the varieties of bricks, pottery, and porcelain. These, if baked in a strong heat, give fire with steel; a property that may be attributed to the siliceous earth they contain, which cannot act on the steel unless firmly set in the hardened clay. The dimensions of pottery are less, the greater the heat to which the article has been subjected. On this property is constructed a thermometer for measuring the heat of furnaces, by igniting a small brick of known dimensions therein, and afterward measuring its contraction. Baked clay is no longer kneadable with water, though as finely pulverized as mechanical means can go. Hence it has been inferred, that clays owe their ductility to a kind of gluten, which is supposed to be dissipated by heat. See BRICKS and POTTERY.

2. *Barytes, or Heavy Earth.*—This earth, which derives its name from the weight of its compounds, has never been found native, in a pure state. Its sulphat is most common, and has long been known by the names of *heavy spar* and *marmor metallicum*. At a mine at Anglezark, near Chorly, in England, the carbonat of barytes is found in large quantity. This may be decomposed by intense heat. Mr.

Henry gives the following process, (which is nearly the same Pelletier used,) for procuring the pure earth.

Let the native carbonat be powdered and sifted through a fine sieve; mix it with an equal bulk of wheaten flour; and make it into a ball with water. Put this ball into a crucible one third full of char coal powder; cover it, and surround it with more of the powder; lute on a cover; and expose it for two hours to the most violent heat that can be raised in a wind furnace. When cold, take out the ball, and on adding water to it great heat will be emitted, and the barytes dissolved. The filtered solution on cooling will shoot into beautiful crystals.

Barytic water, like limewater, abstracts carbonic acid from the air, till the whole of the earth is converted into carbonat, and precipitated. See ALKALIES.

Barytes is an active poison, as are most of its salts, particularly the carbonat.

3. *Glucine.*—This earth was discovered by Vauquelin, first in the aqua marina, and afterward in the emerald, in the winter of 1798. Its name is derived from its distinguishing character of forming with acids salts that are sweet to the taste. The following is his method of obtaining it:

Let 100 parts of beryl, or emerald, be reduced to a fine powder, and fused in a silver crucible with 300 of pure potash. Let the mass be diffused in water, and dissolved by adding muriatic acid. Evaporate the solution, taking care to stir it toward the end: mix the residuum with a large quantity of water, and filter, to separate the silex. Precipitate the filtered liquor, which contains the muriats of alumine and glucine, with carbonat of potash; wash the precipitate, and dissolve it in sulphuric acid. Add a certain quantity of sulphat of potash, evaporate, and crystals of alum will be obtained. When no more alum is afforded by adding sulphat of potash and evaporating, add a solution of carbonat of ammonia in excess, shake the mixture well, and let it stand some hours, till the glucine is redissolved by the excess of carbonat of ammonia, and nothing but the alumine remains at the bottom of the vessel. Filter the solution, evaporate to dryness, and expel the acid from the carbonat of glucine by slight ignition in a crucible. Thus 15 or 16 per cent of pure glucine will be obtained.

Glucine thus obtained is a white, soft powder, light, insipid, and adhering to the tongue. It does not change vegetable blues. It does not harden, shrink, or agglutinate by heat; and is infusible. It is insoluble in water, but forms with it a slightly ductile paste.

4. *Lime, or Calcareous Earth.*—It predominates in most stones which are soft enough to be scratched with a knife. These are chalk, limestone, marble, spars, gypsum, or plaster-stone, and various others. As the lime is most frequently combined with carbonic acid, it is usual for mineralogists to drop a small quantity of nitric acid upon the stones they are desirous of classing; and if they froth by the escape of the acid, they conclude that lime enters into the composition. To obtain pure calcareous earth, powdered chalk must be repeatedly boiled in water, which will deprive it of the saline impurities it frequently contains. It must then be dissolved in distilled vinegar, and precipitated by the addition of concrete volatile alkali. The precipitate, when well washed and dried, will consist of lime united to carbonic acid; the latter of which may be driven off by heat, if necessary.

If chalk, marble, limestone, spar, or any other specimens of this earth, containing carbonic acid, be exposed to continued ignition, they give out carbonic acid and water, to the amount of near half their weight. The remainder, consisting chiefly of lime, has a strong tendency to combination, and attracts water very powerfully. The addition of water to lime produces a very considerable heat, attended with noise, and agitation of the parts, which break asunder; a considerable vapour arises, which carries up with it part of the lime; and a phosphoric light is seen, if the experiment be made in the dark. Lime thus saturated with water is said to be slaked. Water dissolves about one five-hundredth part of its weight of lime, and is then called lime-water. This solution has an acrid taste, and turns syrup of violets to a green colour. If lime-water be exposed to the open air, the lime attracts carbonic acid, and is by this means converted into chalk; which, not being soluble in water, forms a crust on the surface, formerly called cream of lime; which, when of a certain thickness, breaks, and falls to the bottom: and in this way the whole of the lime will in time be separated. If the fire have been too violent in the burning of lime, the stone becomes hard, sonorous, and incapable of absorbing water with the requisite degree of avidity. This effect seems to arise from part of the calcareous earth having entered into fusion with the clay, flint, or other contaminating earths, with which it forms a glass that covers and defends the rest.

The paste of lime and water, called mortar, has a degree of adhesion and ductility, though much less than clay. When dry, it is more or less friable, like chalk. A mixture of sand, or broken earthen vessels, greatly increases its firmness, which it seems to effect by rendering it more difficult for the parts to be removed with respect to each other. When mortar is left to dry by the gradual evaporation of its superfluous water, it is very long before it obtains its utmost degree of firmness. But if dry quick-lime be mixed with mortar, it gradually absorbs the superfluous water, and the mass becomes solid in a very short time. See CEMENT.

Lime has an affinity for tannin, whence it is probable that a portion of it is retained in tanned leather, perhaps not to the improvement of its quality. It has an edulcorative power with respect to animal oils, by combining with the putrid gelatine in them; but its coagulative action on them is too strong to admit of its being used for this purpose with advantage, unless in small quantity. Feathers, however, may be very conveniently cleaned by steeping three or four days in strong lime-water, and afterward washing and drying them.

Though infusible in the strongest heat of our furnaces, it is nevertheless a very powerful flux, with regard to mixtures of the other earths. These are all fusible by a proper addition of lime. Compounds are still more fusible; for any three of the five well known earths may be fused into perfect glass, if they be mixed together in equal portions, provided the calcareous be one of them. See GLASS. See also ALKALIES.

The earthy part of animals is chiefly, if not altogether, calcareous: in most cases it is united with phosphoric acid, but frequently with the carbonic.

5. *Magnesia.*—This earth is of modern discovery. Bergmann has written a treatise upon it in his usual masterly manner. It first began to be known at Rome under the name of Count Palma's powder, where it was offered by a regular canon as a remedy for all disorders. Its resemblance in many respects to calcareous earth induced many to consider it at first as the same thing; but Mr. F. Hoffmann first proved it to be essentially different. This was afterward discovered by Dr. Black of Edinburgh, and Margraaf of Berlin, unknown to each other.

Magnesia is a white powder, perfectly void of taste or smell. It is very little soluble, water taking up about a two thousandth part only: yet it appears to have some affinity for water, as, if it be moistened with water, and then dried, it gains about 18 per cent. It changes syrup of violets green, but its filtered solution does not. With the acids it forms very soluble and bitter salts. It is not soluble in caustic alkalies. It has a great affinity for alumine.

No effervescence or loss of weight should ensue, on adding dilute sulphuric acid, to pure magnesia; it should dissolve entirely in the acid; and, when largely diluted, oxalat of ammonia, should occasion no precipitate in the solution.

The carbonat of magnesia shows signs of fusion in a strong heat; but pure magnesia resists the most powerful focus of the burning glass, without either contracting in its dimensions, or undergoing any other change. It flows easily with borax, and the microcosmic salt: with equal parts of flint and borax, it assumes the form of a beautiful coloured glass, resembling the topaz. With equal parts of flint and fluor spar, it affords a glass resembling the chrysolite: and with an equal portion of fluor alone, it corrodes and runs through the crucible. Almost any proportion of lime, pure clay, and flint is made by it to flow in the fire; and with four times its weight of green glass, it affords a mass resembling porcelain, and hard enough to give fire with steel. It will not flow with an equal weight singly, either of flint, quicklime, barytes, glass, lead, potash, or sulphat of potash: but common clay runs with it into a hard mass.

Though this earth appears to be very extensively diffused over the surface of the globe, yet it is undoubtedly less plentiful than the calcareous, siliceous, or aluminous earths. Most of the native specimens of the magnesian genus, are remarkable for a certain soapy or greasy feel. Of these, the most common are, steatites of a greenish colour, and soft enough to be scraped with the nail; soap rock, lapis ollaris, or Spanish chalk, of a yellow or whitish colour, or black, though rarely, rather harder than steatites, and so easily wrought and turned, that pots are made of it. Asbestos, amianthus, and the Venetian and Muscovy talc are included in this genus.

In the state of phosphat, it is said by Fourcroy and Vauquelin, to exist in the bones of all the animals they examined, those of man excepted. Giobert has found, that a white earth employed near Turin, in the fabrication of porcelain, and considered as pure alumine, contains 80 per cent. of subcarbonat of magnesia, and sometimes 90, without a grain of alumine.

According to him, it contains, on an average, magnesia 68, carbonic acid 12, silex 15·6, sulphat of lime 1·6, water. It is said to be of extraordinary good quality for making pottery. This is dug at Baudissero, and a somewhat similar earth is found at Castellamonte, in the same neighbourhood. See ALKALIES.

Under the name of calcined magnesia, the pure earth is much used in medicine, where absorbents are indicated, and the carbonic acid might be detrimental.

6. *Silex, or, flinty earth*—The most eminent characters of this earth are, its hardness and insolubility in almost every acid. It exists nearly in a state of purity, in rock-crystal, and abounds in all natural bodies, which are hard enough to strike fire with the steel. In the pulverulent form, it possesses a singular degree of asperity to the touch, and has not the least disposition to adhere and become kneadable by the addition of water. No acid dissolves it but that of the fluor spar, which suspends it abundantly, while in the aëriform state, less so when dissolved in hot water, and very sparingly when cold. The fixed alkalies dissolve it both in the humid and the dry way. In the humid way they combine with about one-sixth part of their weight, when the siliceous earth is in a state of extreme division. And in the dry way they take up a very large proportion, according to the degree of heat made use of. From one to two parts of alkali, with one part of silex, form hard permanent glass; but, if the salt exceed this proportion, the compound will attract humidity from the air, and assume the liquid state. This fluid, or combination of silex with water, by the medium of alkali, is known by the name of the liquor of flints. The addition of an acid will seize the alkali, and throw down the siliceous earth in a state of purity; and accordingly, this is the process by which it is to be obtained in a disengaged state. That is to say, let rock crystal be dissolved by strong fusion in four times its weight of fixed alkali, and the mass dissolved in water: let muriatic acid be then added in excess; this will seize the alkali, and form soluble salts, with any other earths that may be present; but the siliceous earth will fall to the bottom. Repeated ablutions in distilled water will separate all the extraneous saline fluid, which may be interposed between these particles after decantation, and the dried powder will consist of pure silex.

With metallic oxides, more especially those of lead, it combines by fusion, and forms glass of a dense texture, and strong refractive power. See GLASS.

Rock crystal, quartz, flint, gritstone, jasper, and most of the precious stones or gems, owe their distinguishing qualities to siliceous earth, and are therefore considered as specimens of this genus.

7. *Strontia*. About twenty years ago, a mineral was brought to Edinburgh by a dealer in fossils from a lead-mine at Strontian, in Argyleshire, which was generally considered as a carbonat of barytes. It has since been found in France, Sicily, and in Pennsylvania. Dr. Crawford first observed some difference between its solution in muriatic acid, and that obtained from the carbonat of barytes of Anglezark, and thence supposed it to be a new earth. Dr. Hope, of Edinburgh, had entertained the same opinion, and confirmed it by experiments in 1791. Kirwan, Klaproth, Pelletier, and Sulzer, did the same. The carbonic acid may be expelled by a heat of 140° of Wedgwood, leaving the strontia behind: or by dissolving in the nitric acid, and driving this off by heat.

Pure strontia is of a grayish white colour; a pungent, acrid taste; and when powdered in a mortar, the dust that rises irritates the lungs and nostrils. Its specific gravity approaches that of barytes. It requires rather more than 160 parts of water at 60° to dissolve it; but of boiling water much less. On cooling, it crystallizes in thin, transparent, quadrangular plates, generally parallelograms, seldom exceeding a quarter of an inch in length, and frequently adhering together. The edges are most frequently bevilled from each side. Sometimes they assume a cubic form. These crystals contain about ·68 of water; are soluble in 51·4 times their weight of water at 60°, and in little more than twice their weight of boiling water. They give a blood red colour to the flame of burning alcohol. The solution of strontia changes vegetable blues to a green. Strontia combines with sulphur either in the wet or dry way, and its sulphuret is soluble in water.

In its properties, strontia has a considerable affinity to barytes. It differs from it chiefly in being infusible, much less soluble, of a different form, weaker in its affinities, and not poisonous. Its saline compounds afford differences more marked.

8. *Yttria*. This also is a new earth, discovered in 1794, by Prof. Gadolin, in a stone from Ytterby, in Sweden, called the gadolniite.

It may be obtained most readily by fusing the gadolinite with two parts of caustic potash, washing the mass with boiling water, and filtering the liquor, which is of a fine green. This liquor is to be evaporated, till no more oxide of manganese

falls down from it in a black powder; after which the liquid is to be saturated with nitric acid. At the same time digest the sediment, that was not dissolved, in very dilute nitric acid, which will dissolve the earth with much heat, leaving the silex, and the highly oxided iron, undissolved. Mix the two liquors, evaporate them to dryness, redissolve, and filter, which will separate any silex or oxide of iron, that may have been left A few drops of a solution of carbonat of potash, will separate any lime that may be present; and a cautious addition of hydro-sulphuret of potash, will throw down the oxide of manganese that may have been left; but, if too much be employed, it will throw down the yttria likewise. Lastly, the yttria is to be precipitated by pure ammonia, well washed, and dried.

Yttria is perfectly white, when not contaminated with oxide of manganese, from which it is not easily freed. Its specific gravity is 4·842. It has neither taste nor smell. It is infusible alone; but with borax melts into a transparent glass, or opake white, if the borax were in excess. It is insoluble in water, and in caustic fixed alkalies: but it dissolves in carbonat of ammonia, though it requires five or six times as much as glucine. It is soluble in most of the acids. The oxalic acid, or oxalat of ammonia, forms precipitates in its solutions, perfectly resembling the muriat of silver. Prussiat of potash, crystallized and redissolved in water, throws it down in white grains; phosphat of soda, in white gelatinous flakes; infusion of galls, in brown flocks.

Some chemists are inclined to consider yttria rather as a metallic than as an earthy substance; their reasons are its specific gravity, its forming coloured salts, and its property of oxigenizing muriatic acid, after it has undergone a long calcination.

9. *Zircon*—was first discovered in the jargon, of Ceylon, by Klaproth, in 1789, and it has since been found in the hyacinth. To obtain it the stone should be calcined and thrown into cold water, to render it friable, and then powdered in an agate mortar. Mix the powder with nine parts of pure potash, and project the mixture by spoonsful into a red hot crucible, taking care that each portion is, fused before another is added. Keep the whole in fusion, with an increased heat, for an hour and an half. When cold, break the crucible, separate its contents, powder, and boil in water, to dissolve the alkali. Wash the insoluble part; dissolve in muriatic acid; heat the solution, that the silex may fall down; and precipitate the zircon by caustic fixed alkali. Or the zircon may be precipitated by carbonat of soda, and the carbonic acid expelled by heat.

Zircon is a fine white powder, without taste or smell, but somewhat harsh to the touch. It is insoluble in water; yet, if slowly dried, it coalesces into a semi transparent yellowish mass, like gum arabic, which retains one-third its weight of water. It unites with all the acids. It is insoluble in pure alkalis; but the alkaline carbonats dissolve it. Heated with the blow-pipe it does not melt, but emits a yellowish phosphoric light. Heated in a crucible of charcoal, bedded in charcoal powder, placed in a stone crucible, and exposed to a good forge fire for some hours, it undergoes a pasty fusion, which unites its particles into a gray opake mass, not truly vitreous, but more resembling porcelain. See AGRICULTURE.

EARTH (FULLER'S).—Among the useful researches, for which we are indebted to the illustrious Bergmann, we find one upon Lithomarga, or stone marle; which seems to differ from common marle in its composition, chiefly in possessing a much larger portion of siliceous and less of calcareous earth. Fullers earth is one of the most useful varieties of Lithomarge.

Cronstedt describes Lithomarge under the following general characters: First, when dry, it is smooth and slippery like hard soap. Secondly, It is not perfectly dissoluble in water: but when immersed in that fluid it falls into pieces of greater or less magnitude, or in such a manner as to assume the appearance of curds. Thirdly, in the fire it easily melts into a white or reddish frothy slag, which is considerably larger than before, in consequence of its porosity. Fourthly, Its fracture is irregularly convex or concave.

Lithomarge is found in Lemnos, Tartary, and in Hampshire (England.)

The properties required in a good fuller's earth are, that it should contribute to the washing away all impurities, and promote that curling and intermixture of the hairs of the woollen cloth, which thicken its texture, and give it the desired firmness. Both probably depend on its detergent quality, that clears away all the unctuous matter of the wool, and renders its parts capable of becoming more perfectly entangled together by the mechanical action of fulling; an effect not so likely to take place when the fibres or hairs are disposed by grease to slide easily over each other. The detergent power resides in all clays, but is doubtless greatly increased by the siliceous

earth, which may be considered as the brush, while the clay serves as the soap. This is familiarly shown, by the common practice of adding sand to soap, which renders it much more detergent; but at the same time more capable of injuring the substances to which it is applied, and that more especially when the sand is coarse. Fuller's earth is bad, if the sand be not exceedingly fine; and the superior excellence of the Hampshire fuller's earth seems to depend more on the fineness of its parts, than on their proportions, as is shewn by the experiment of boiling it in water; after which it passes more plentifully through the filter than any of the other lithomargæ.

EARTHEN WARE, see POTTERY.

EBONY, an exceedingly hard and heavy wood, imported from the East-Indies; it admits of being very highly polished, for which reason it is used chiefly for veneering cabinets, in Mosaic work, &c.

Ebony is of various colours, viz. black, red, and green; but the first is that most generally known, and used. Cabinet-makers, inlayers, and others, frequently substitute pear-tree, and other wood, for ebony, by giving the former a black colour; which some effect by washing it in a hot decoction of gall-nuts, and after it is dry, by rubbing it over with ink, and polishing it by means of a hard brush and a little wax: others heat, or almost burn their wood, till it becomes black, so that it acquires such a degree of hardness, that, when properly polished, it can with difficulty be distinguished from genuine ebony. See DYEING OF WOOD.

EMERY.—The best sort is of a light gray colour, but becomes brown by calcination. It is brought principally from the Archipelago, particularly from the Isle of Naxos, and is much used for grinding and polishing. Different specimens of emery has been analysed by Mr. Tennant, one of which gave .80 alumine, 0.3 silex, 0.4 iron, and 0.3 insoluble matter: a second, .65 alumine, 0.8 silex, 0.32 iron, 0.4 residuum. Emery has been found in the United States, or at least a stone, which, when pulverized, answers all the purposes of emery. The discovery of this substance in the United States is of considerable importance for the polishing of muskets, swords, &c. and for the grinding or polishing of various parts of machinery. In Europe a soldier is allowed a certain quantity of emery to polish his musket.

ENAMEL or ENAMELLING. Enamelling is an art, which has been practised in this country, as well as in Europe. we have seen specimens of American enamel, equal to the foreign.

The delicate and beautiful art of enamelling consists in the application of a smooth coating of vitrified matter, (transparent or opake, and without colour, figures, and other ornaments) to a bright polished metallic substance. It is therefore a kind of varnish made of glass, and melted upon the substance to which it is applied, and affording a fine uniform ground, for an infinite variety of ornaments, which are also fixed on by heat.

The general principles on which enamelling is founded, are on the whole very simple, but perhaps there is none of all the chemico-mechanical arts which requires, for the finer parts, a greater degree of practical skill and dexterity, and of patient and accurate attention to minute processes.

The concealment observed by those who profess this art, is proportioned to the difficulty of acquiring it; the general chemist must therefore content himself with the general principles of enamelling, and the detail of those particulars that are commonly known.

Though the term enamelling is usually confined to the ornamental glazing of metallic surfaces, it strictly applies to the glazing of Pottery or porcelain, the difference being only that in the latter the surface is of baked clay. With regard to the composition of coloured enamels (which are all tinged by different metallic oxyds) a very general account of the substances used will suffice in this place, and the rest of the subject may be properly referred to the article of coloured GLASS. The enamelling on metals therefore will only be noticed in this place.

The only metals that are enamelled are gold and copper, and with the latter the opake enamels are only used. Where the enamel is transparent and coloured, the metal chosen should be of that kind as not only to have its surface unalterable when fully red-hot, but also to be in no degree chemically altered by the close contact of melted glass, containing an abundance of some kind of metallic oxyd. This is the chief reason why coloured enamelling on silver is impracticable, though the brilliancy of its surface is not impaired by mere heat, for if (for example) an enamel made yellow with oxyd of lead or antimony is laid on a surface of bright silver, and kept melted on it for a certain time, the silver and the enamel act on each other so powerfully that the colour soon changes from a yellow to an orange, and lastly to a dirty olive. Copper

is equally altered by the coloured enamels, so that gold is the only metal which can bear the long contact of the coloured glasses at a full red heat, without being altered by them.

The simplest kind of enamel is that fine white opake glass which is applied to the dial-plate of watches. The process of laying it on (which may serve as a general example of the art) is the following:

A piece of thin copper sheet hammered, of the requisite convexity, is first accurately cut out, a hole drilled in the middle of the axis of the hands, and both the surfaces made perfectly bright with a scratch brush.

A small rim is then made round the circumference with a thin brass band rising a little above the level, and a similar rim round the margin of the central hole. The use of these is to confine the enamel when in fusion, and keep the edges of the plate quite neat and even. The substance of the enamel is a fine white opake glass, the materials of which will be presently mentioned. This is bought in lump by the enamellers, and is first broken down with a hammer, then ground to a sufficiently fine powder, with some water in an agate mortar; the superfluous water being then poured off, the pulverized enamel remains of about the consistence of wetted sand, and is spread very evenly over the surface of the copper plate by many dextrous manipulations. On most enamellings, and especially on this it is necessary also to counter enamel the under or concave surface of the copper plate to prevent its being drawn out of its true shape by the unequal shrinking of the metal and enamel on cooling. For this kind of work, the counter-enamel is only about half the thickness on the concave, as on the convex side. For flat plates the thickness is the same on both sides.

The plate covered with the moist enamel powder is warmed and thoroughly dried, then gently set upon a thin earthen ring that supports it only by touching the outer rim, and put gradually into the red-hot muffle of the enameller's furnace. This furnace is constructed somewhat like the assay furnace, but the upper part alone of the muffle is much heated, and some peculiarities are observed in the construction to enable the artist to govern the fire more accurately.

The precise degree of fire to be given here as in all enamelling, is that at which the particles of the enamel run together into an uniform pasty consistence, and extend themselves evenly over the surface, shewing a fine polished face, carefully avoiding on the other hand so great a heat as would endanger the melting of the thin metallic plate. When the enamel is thus seen to *sweat down*, as it were, to an uniform glossy glazing, the piece is gradually withdrawn and cooled, otherwise it would fly by the action of the cold air.

A second coating of enamel is then laid on and fired as before, but this time the finest powder of enamel is taken, or that which remains suspended in the washings. It is then ready to receive the figures and division marks, which are made of a black enamel, ground in an agate mortar with much labour to a most impalpable powder, worked up on a pallet with oil of lavender, or spike, and laid on with an extremely fine hair brush. The plate is then stoved to evaporate the essential oil, and the figures burnt in as before. The polishing with tripoli and minuter parts of the process need not be here mentioned.

If the enamel be chipped off a dial plate (which may be done with the utmost ease by bending it backwards and forwards, as the adhesion between the metal and glazing is very slight) the part immediately in contact with the copper will be found deeply and nearly uniformly browned, which shews how unfit copper alone would be for the transparent enamels.

The regulation of the fire appears to be the most difficult of all the parts of this nice process, particularly in the fine enamelling of gold for ornamental purposes, of designs, miniatures and the like, where three, four, or sometimes five separate firings are required. If the heat is too low, the enamel does not spread and vitrify as it ought; if too high, it may be enough to melt the metal itself, whose fusing point is but a small step above that of the enamel, or else, (what is an equal mortification to the artist) the delicate figures, laid on with so much care and judgment, melt down in a moment, and the piece exhibits only a confused assemblage of lines and fragments of designs.

The exact composition of the opake white enamel, is a matter of considerable importance, and is procured by the enamellers, from persons whose business it is to prepare it. A good enamel of this kind, fit to be applied both to porcelain and metals, should be of a very clear fine white, so nearly opake, as only to be translucent at the edges, and exposed to a moderate red heat, it should run into that kind of paste, or imperfect fusion, which allows it to extend itself freely and uniformly, and to acquire a glossy even surface, without however fully melting into a thin glass. The opake white of this enamel, is given

by the oxyd of tin, which possesses, even in a small proportion, the property of rendering vitrescent mixtures white, and opake, or in still less proportion, milky, and when otherwise coloured, opalescent. The oxyd of tin is always mixed with three or four times its quantity of oxyd of lead, and it appears necessary that the metals should be previously mixed by melting, and the alloy then calcined.

The following are the directions given by Clouet, for the composition of this enamel. Mix 100 parts of pure lead, with from 20 to 25 of the best tin, and bring them to a low red heat in an open vessel.

The mixture then burns nearly as rapidly as charcoal, and oxidates very fast. Skim off the crusts of oxyd, successively formed, till the whole is thoroughly calcined. It is better then to mix all the skimmings and again heat as before till no flame arises from them, and the whole is of an uniform grey colour. Take 100 parts of this oxyd, 100 of sand, and 25 or 30 of common salt, and melt the whole in a moderate heat. This gives a greyish mass, often porous and apparently imperfect, but which however runs to a good enamel when afterwards heated. This is the enamel used for porcelain, but for metals and finer works, the sand is previously calcined in a very strong heat, with a fourth of its weight, or, if a more fusible compound is wanted, as much of the oxyd of tin and lead, as of salt is taken, and the whole melted to a white porous mass. This is then employed instead of the rough sand, as in the above-mentioned process. The above proportions however are not invariable, for if more fusibility is wanted, the dose of oxyd is encreased, and that of the sand diminished, the quantity of common salt remaining the same. The sand employed in this process according to M. Clouet, is not the common sort, however fine, but a micaceous sand, in which the mica forms about one-fourth of the mixture.

Neri, in his valuable treatise on glass-making, has given long ago the following proportions, for the common materials of all the opake enamels, which Kunckel and other practical chemists have confirmed. Calcine 30 parts of lead, with 33 of tin, with the precautions mentioned above. Take of this calcined mixed oxyd 50 lb. and as much of powdered flints, (prepared by being thrown into water when red-hot, and then ground to powder,) and 8 ounces of salt of tartar; melt the mixture in a strong fire kept up for 10 hours, after which reduce the mass to powder. This is the common material for the opake enamels, and is of a grey white. To make this fine enamel quite white, mix 6lb. of this material with 48 grains of the best black oxyd of manganese, and melt in a clear fire. When fully fused, throw it into cold water, then re-melt and cool as before two or three times, till the enamel is quite white and fine. Kunckel observes on this process, that he tried it without the oxyd of manganese, but the enamel instead of being milk-white was blueish and not good, so that there is no doubt, but that this oxyd is highly important. If too much is used, the enamel becomes of a rose-purple. For further observations on the use of manganese in vitrescent mixtures, see the article GLASS.

Coloured enamels, are composed of a common basis, which is a fusible mixture of vitrifiable materials, and of some metallic oxyd. In general the coloured enamels are required to be transparent, in which case the basis is a kind of glass composed of borax, sand, and oxyd of lead, or other vitrescent mixtures, in which the proportion of saline or metallic flux, is more or less according to the degree of heat, that the colouring oxyd will bear without decomposition. When the coloured enamel is to be opake or opalescent, a certain portion of the white opake enamel, or of the oxyd of tin, is added to the mixture. The most beautiful and costly colour, known in enamelling, is an exquisitely fine rich red with a purple tinge, given by the salts and oxyds of gold, especially the purple precipitate formed by tin in one form or other, and nitro-muriat of gold, and also by the fulminating gold. This beautiful colour requires much skill in the artist, to be fully brought out. It is said that when most perfect, it should come from the fire quite colourless, and afterwards receive its colour by the flame of a candle. Gold colours will not bear a violent fire.

Other and commoner reds, are given by the oxyd of iron, but this requires the mixture of alumine or some other substance, refractory in the fire; otherwise, at a full red heat, the colour will degenerate into black.

Yellow is given either by the oxyd of silver alone, or by the oxyds of lead and antimony, with similar mixtures to those required for iron. The silver is as tender a colour as gold, and readily injured or lost in a high heat.

Green is given by the oxyd of copper, or it may also be produced by a mixture of blue and yellow colours.

Blue is given by cobalt, and this seems

of all enamel colours the most certain, and easily manageable.

Black is produced by a mixture of cobalt and manganese.

Red enamel is afforded by the oxyd of gold, and also by that of iron. The former is the most beautiful.

Under the article of coloured Glasses, this subject will be noticed more at large.

The reader may conceive how much the difficulties of this nice art are increased, when the object is not merely to lay an uniform coloured glazing, on a metallic surface, but also to paint that surface with figures and other designs, that require extreme delicacy of outline, accuracy of shading, and selection of colouring. The enamel painter has to work, not with actual colours, but with mixtures which he only knows from experience, will produce certain colours, after the delicate operation of fire; and to the common skill of the painter in the arrangement of his pallet, and choice of his colours, the enameller has to add, an infinite quantity of practical knowledge of the chemical operation of one metallic oxyd on another, the fusibility of his materials, and the utmost degree of heat at which they will retain not only the accuracy of the figures which he has given, but the precise shade of colour, which he intends to lay on.

Painting in enamel requires a succession of firings; first of the ground which is to receive the design, and which itself requires two firings, and then of the different parts of the design itself. The ground is laid on in the same general way, as the common watch-face enamelling, already described. The colours are the different metallic oxyds, melted with some vitrescent mixture, and ground to extreme fineness. These are worked up with an essential oil (that of spike is preferred, and next to it oil of lavender,) to the proper consistence of oil colours, and are laid on with a very fine hair brush. The essential oil should be very pure, and the use of this, rather than any fixed oil, is probably that the whole may evaporate completely in a moderate heat, and leave no carbonaceous matter in contact with the colour when red-hot, which might affect its degree of oxidation, and thence the shade of colour which it is intended to produce.

As the colour of some vitrified metallic oxyds, (such as that of gold,) will stand only at a very moderate heat, whilst others will bear, and even require, a higher temperature to be properly fixed, it forms a great part of the technical skill of the artist, to apply the different colours in proper order; fixing first those shades which are produced by the colours, that will endure the highest heat, and finishing with those that demand the least heat. The outline of the design is first traced on the enamel, ground and burnt in; after which the parts are filled up gradually with repeated burnings, to the last, and finest touches of the tenderest enamel.

Transparent enamels are scarcely ever laid upon any other metal than gold, on account of the discoloration, produced by other metals, as already explained. If however, copper is the metal used, it is first covered with a thin enamel coating, over which gold leaf is laid and burnt in, so that in fact it is still this metal, that is the basis of the ornamental enamel.

With regard to the vast number of important minutiæ in the selection and order of applying the colours, the management of the fire, &c. &c. almost the whole of what is known on this subject, is confined to the practical artist, nor could this knowledge, if obtained, interest the general reader.

The art of enamelling on metals is treated at full length by Mr. Brogniart in the *Annales de Chimie*, vol. 9.

The following circumstances, in addition to what we have said, may be useful.

We have seen, that oxide of copper affords a green; manganese, a violet; cobalt, a blue; and iron, a very fine black. A mixture of these different enamels produces a great variety of intermediate colours, according to their nature and proportion. In this branch of the art, the coloured enamels are sometimes mixed with each other, and sometimes the oxides are mixed before they are added to the vitreous bases.

The enameller, who is provided with a set of good colours, is very far from being in a situation for practising the art, unless he be skilled in the methods of applying them, and the nature of the grounds upon which they are to be laid. Many of the metals are too fusible to be enamelled, and almost all of them are corroded by the action of the fused glass. For this reason, none of the metals are used but gold, silver, and copper. Platina has indeed been used; but of its effects and habitudes with enamels very little can be said, for want of a sufficient number of experiments.

The purest gold of 24 carats is calculated to produce the best effect with ena-

mel. 1. Because it entirely preserves the metallic brilliancy without undergoing any oxidation in the fire. 2. Being less fusible, it will admit of a more refractory, and consequently a harder and more beautiful enamel. It is not usual, however, to enamel upon finer gold than 22 carats; and the operation would be very defective, if a coarser kind than that of 18 carats were used. For in this case more alkali must be added to the enamel, to render it more fusible, and this addition would at the same time render it softer and less brilliant.

Rejecting all these exceptions, we give the following description, by way of example, of fixing a transparent blue enamel upon gold of 22 carats.

The artist begins his operation by breaking the enamel into small pieces in a steel mortar, and afterward pulverizing it in a mortar of agate. He is careful to add water in this part of his process, which prevents the splinters of glass from flying about. There are no means of explaining the point at which the trituration ought to be given up, as this can be learned only by experience. Some enamels require to be very finely triturated; but others may be used in the form of a coarse powder. As soon as he apprehends that his enamel is sufficiently pounded, he washes it by agitation in very clear water, and pouring off the fluid as it becomes turbid. This operation, which is made for the purpose of carrying off dust, and every other impurity from the enamel, is continued until the water comes off as clear as it was poured on.

The workman puts his enamel, thus prepared, in a white china or earthen saucer, with water poured on it to the depth of about one tenth of an inch. He afterward takes up this enamel with an iron spatula, as equally as possible. As the enamel here spoken of is transparent, it is usual to ornament the surface of the gold with rose work, or other kinds of works, calculated to produce a good effect through the enamel.

The thickness of this first layer depends entirely upon its colour: delicate colours, in general, require that it should have no great thickness.

The moist enamel, being thus placed, is dried by applying a very clean half-worn linen cloth to it, which must be very carefully done, to avoid removing the enamel by any action of wiping.

In this state the piece is ready for the fire. If it be enamelled on both sides, it is placed upon a tile, or iron plate, hollowed out in such a manner, that the uncovered edges of the piece alone are in contact with the support. But if it be enamelled on one side only, it is simply laid upon the plate, or on a tile. Two things, however, require to be attended to. 1. If the work be very small, or not capable of being enamelled on its opposite side, the iron plate must be perfectly flat, in order that the work may not bend when softened by heat. 2. If the work be of considerable size, it is always counter-enamelled if possible; that is to say, an enamel is applied on the back surface, in order to counteract the effect which the other coating of glass might produce on the soft metal, when it came to contract by cooling.

The enameller's furnace is square and built of bricks, bedded in an earth proper for the purpose. It may be considered as consisting of two parts, the lower part, which receives a muffle, resting on the floor of the furnace, and open on both sides.

The upper part of the furnace consists of a fire-place, rather larger and longer than the dimensions of the muffle. This fire-place contains the charcoal, which must surround the muffle on all sides, excepting at the bottom. The charcoal is put in at a door above the muffle, which is closed when the fire is lighted. A chimney proceeds from the summit of the furnace with a moderate aperture which may be closed at the pleasure of the artist, by applying a cast iron plate to it. This furnace differs from that of the assayer in the circumstance, that it is supplied with air through the muffle itself: for, if the draught were beneath the muffle, the heat would be too strong, and could not be stopped when requisite.

As soon as the fire is lighted, and the muffle has obtained the requisite degree of ignition, the charcoal is disposed toward the lower part of the muffle in such a manner, as that it shall not fall upon the work, which is then conveyed into the muffle with the greatest care upon the plate of iron or earthen-ware, which is taken up by long spring pincers. The work is placed as near as possible at the farther extremity of the muffle; and as soon as the artist perceives a commencement of fusion, he turns it round with great delicacy, in order that the fusion may be very uniform. And as soon as he perceives that the fusion has completely taken place, he instantly removes it out of the furnace: for the fusion of gold happens so very near that of the enamel, that a neglect of a few seconds might be attended with considerable loss.

When the work is cooled, a second

coat of enamel is applied in the same manner as the first, if necessary. This, and the same cautious management of the fire, are to be repeated for every additional coat of enamel the nature of the work may demand.

As soon as the number of coatings are sufficient, it becomes necessary to give an even surface to the enamel, which, though polished by the fire, is nevertheless irregular. This is done with an English fine-grained file and water. As the file wears smooth, sand is used. Much precaution and address are required in this part of the work, not only because it is easy to make the enamel separate in splinters from the metal, but likewise because the colour would not be uniform if it were to be ground thinner at one part than at another.

The deep scratches of the file are in the next place taken out, by rubbing the surface with a piece of deal wood and fine sand and water. A polish is then given by a second ignition. This polish, however, is frequently insufficient, and not so perfectly uniform as the delicacy of the work may require.

The substance used by the enamellers, as a polishing material, is known by the name of rotten-stone; which is prepared by pounding, washing, decanting off the turbid water, suffering the fine suspended particles to subside from this water, and lastly levigating it upon a glass plate.

The work is then cemented to a square piece of wood with a mixture of resin and brick-dust, and by this means fixed in a vice, as before observed.

The first operation of polishing is made by rubbing the work with rotten-stone upon a small straight bar of pewter. Some delicacy is here required, to avoid scratching or producing flaws in the enamel, by pressing it too hard. In this way the piece is rendered perfectly even: but the last brilliant polish is given by a piece of deal wood and the same rotten-stone.

This is the general method of applying enamels; but some colours require more precaution in the management of the fire.

When different colours are intended to be placed beside one another, they are kept separate by a small edge or prominency, which is left in the gold for that purpose, and is polished along with the enamel.

The enamelling upon silver is effected nearly in the same manner as that of gold; but the changes sustained by the colours upon the silver, by the action of fire, are much more considerable than when gold is used.

Copper is not much used by enamellers, on account of the difficulty which attends the attempt to fix beautiful colours upon it. When this metal is used, the common practice is to apply a coating of opaque white enamel, and upon this other colours, which are more fusible than the white.

A good effect is produced in toys, by leaving part of the gold bare. For this purpose its surface is cut into suitable compartments by the engraver. This, however, is an expensive method, and is for this reason occasionally imitated by applying small and very thin pieces of gold upon the surface of the enamel, where they are fixed by the fire, and afterward covered by a transparent vitreous coating.

After this detail of the art of enamelling, Mr. Brogniart describes a method of taking off the enamel from any toy, without injuring its metallic part. For this purpose, a mixture of common salt, nitre, and alum, in powder, is applied upon the enamel, and the piece put into the furnace. As soon as the fusion has taken place, the piece is suddenly thrown into water, which causes the enamel to fly off either totally or in part. The part which may remain is to be removed by repeating the same operation a second time. See GLASS; also PORCELAIN.

To coat vessels of iron or copper for culinary purposes with an enamel capable of defending the metal from the action of any solvent, and enduring any heat, or transition from heat to cold, appears a desirable object; and many experiments have been made on the subject by Mr. Soen Rinman, of the Royal Academy of Stockholm.

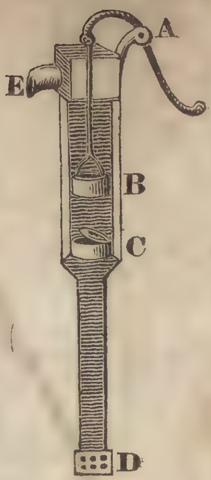
The following compositions he found answer very well on copper. 1. The white semitransparent fluor spar and sulphat of lime in equal quantities, powdered, mixed, and calcined in a white heat; then powdered, made into a thin paste with water, and applied a little warm to the vessel also warmed. When dried and heated gradually to a certain point, a very strong heat, greater than is commonly obtained in an assaying furnace, is to be applied as quickly as possible. 2. Sixty parts of lime, 100 of fluor spar, 60 of gypsum, 20 of quartz, and one of manganese, were calcined, ground, and applied in a similar manner. 3. Four parts of fluor spar, four of gypsum, and one of litharge, melted into a straw-coloured glass, ground, and applied in the same way, required a still stronger heat. 4. Five

parts of fluor spar, 5 of gypsum, 2 of minium, 2 of flint glass, ½ a part of borax, the same of oxide of tin, and one twenty-fifth of a part of oxide of cobalt melted together, made an enamel; which, when ground and applied as the others, fused with a less degree of heat. This Mr. Rinman imagines would have been acted upon in length of time by sulphuric acid. The oxide of cobalt was prepared by saturating a solution of cobalt in aquafortis with common salt, and evaporating to dryness.

As these would not do for iron, he tried the following. 1. Minium 9 parts, flint glass 6, pure potash 2, nitre 2, borax 1, were ground together, put into a covered crucible which they only half filled, and fused into a glass. This poured out on a piece of marble, quenched in water, powdered, and made into a thin paste, was laid on both sides of an iron vessel. After having been dried and heated gradually, the vessel was put under a muffle well heated in an assaying furnace, and in half a minute the enamel melted. The vessel being then withdrawn, was found enamelled of a beautiful black colour, which appeared to be owing to a thin layer of oxided iron seen through the transparent glaze. 2. The same, with one hundredth part of oxide of cobalt, prepared as above, covered the vessel more perfectly with a blue enamel. 3. The same ground with potters' white lead, which consists of 4 parts lead and 1 tin, produced a very smooth gray enamel, more firm and hard than the preceding. A small quantity of red oxide of iron gave it a fine dark red colour. 4. Flint glass 12 parts, minium 18, potash 4, nitre 4, borax 2, oxide of tin 3, oxide of cobalt one-eighth of a part, gave a smooth pearl-coloured enamel, not brittle or subject to crack, and capable of enduring sudden changes of heat and cold, as well as the action of oils, alkalies, and weak acids; but it cannot resist the stronger vegetable acids, and still less the mineral.

These enamels can be applied only on hammered iron, cast iron being too thick to be heated with sufficient quickness. It may be unnecessary to add, none of them will bear hard blows.

ENGINES, for raising water, in Hydraulics. The engines for raising water are numerous: the common pump is the simplest. This useful and domestic machine was invented about one hundred and twenty years before the birth of Christ; but it has been greatly improved, even since the time of Galileo, when the pressure of the atmosphere became more perfectly known.



This pump is formed of a long cylinder of wood or lead, one end of which stands in the water at the bottom of the well. It contains two valves, or hollow pieces of wood, which fit close to the cylinder, with lids opening upwards; the lower valve c remains fixed, but the upper valve B is fastened to the piston rod, and moves up and down by the action of the handle or lever.

The mode of operation. This description supposes that the water in the cylinder of the pump stands no higher than the water in the well, and that the remainder of the cylinder is empty, or rather occupied by air. Now, when the handle of the pump is raised up, the piston B sinks towards C, which condenses the air between B and C, till its resistance forces open the valve or lid; then the air escapes into the upper and open part of the cylinder. As the piston rises, the air which is contained between B and C becomes rarified, and the elasticity of that portion of air which is contained in the cylinder, between the lower valve C and the surface of the water in the well, forces open the lower lid, and a part of it escapes into the rarified space between B and C, which has been formed by the rising of the piston. Thus, by a few strokes of the handle, if the wood or metal of the cylinder be sufficiently close to exclude the air, and the piston and valves be well fitted to the sides of the pipe, the compressive power of the atmosphere will be removed from the surface of that part of the fluid which is contained within the cylinder, and the atmospherical pressure

on the general surface of the well will force up the barrel to any height less than 33 or 34 feet.

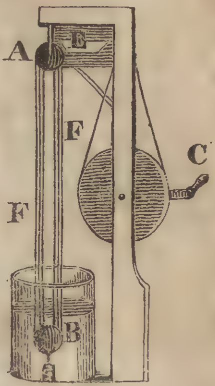
Then, supposing the lower valve to be placed at a less distance than 33 feet from the surface, the ascending water will force it open and get admitted into the cylinder between C and B. When the piston descends, the weight of the water upon the lower valve closes it, and the fluid is forced through the upper by the sinking of the piston; so that, when the handle is returned, the water, which now rests on the upper lid, is carried towards the top of the cylinder, and flows out of the spout E; and the supply from the well, by the compression of the atmosphere upon its surface, forces through the valve C into the cylinder, as the upper piston raises the water by the power of the handle.

After the pump has been worked, if the barrel and pistons be good, the water will stand in the cylinder close to the spout, and ready to flow on the first stroke of the handle.

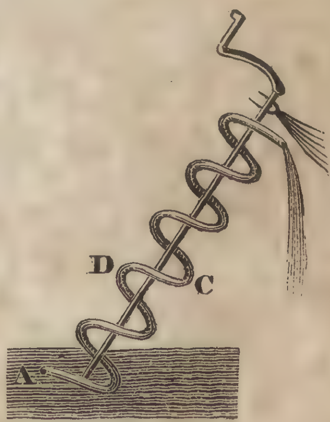
As it is the pressure of the atmosphere alone that forces the water up the barrel of the pump, when the lower valve is more than 33 or 34 feet from the surface of the water in the well, the pressure of the air cannot raise it to the valve, consequently the machine would be useless; but this is prevented by sinking the lower piston in the cylinder till it be actually within the height of the pressure, and by lengthening the piston rod of the upper in proportion to the depth of the lower; this gives an additional weight of fluid to be lifted each stroke, and the power must be proportionate to the handle. See *Adams' Philosophy, Martin's Philosophia Brittanica, &c.*

The *Hair-Rope Pump* is also another means of raising water. It is formed in the following manner:

The three hair ropes F pass in grooves over two pullies A B, and the lines are kept extended by a weight which is fastened to the lower pulley B; at C is a wheel and handle, over which the line passes that joins them to a small multiplying wheel fastened to the well beam, and this acts on the uppermost pulley. When the machine is put in motion, as the hair ropes pass through the water in the well it sinks into their interstices, and by the quickness of their motion it is carried up the ascending ropes in considerable quantities, till it reaches the upper pulley, when it falls into the reservoir E. This method, simple as it may appear, is now used to raise water from a well 90 feet deep, and by tolerable exertion it is capable of drawing up about 9 gallons a minute.



Archimedes Screw Engine.—This mode of raising water is of great antiquity. The fluid enters at A, the mouth of the spiral, and by the surrounding pressure rises to C. When it has attained this point, it cannot afterwards occupy any other part of the spiral than that which is on the under side; for it cannot move from C towards D, because it is situated higher above the horizon; and as this will always be the same in every similar part, it is evident that when the machine is in motion, the water as it is raised by the spiral, will always remain on the under side till it flows out of the spout.



The following is a description of a very cheap Engine for raising Water, in a letter from Mr. H. Sarjeant, of Whitehaven, to Mr. Taylor, Secretary to the Society for the Encouragement of Arts.

"I am sensible that the little engine, a drawing of which accompanies this letter, can lay no great claim to novelty in its principle; nevertheless, it is respectfully submitted to the consideration of the society, how far its simplicity, and cheapness of construction, may render it worthy of their attention, with a view to its being more generally known and used in similar cases.

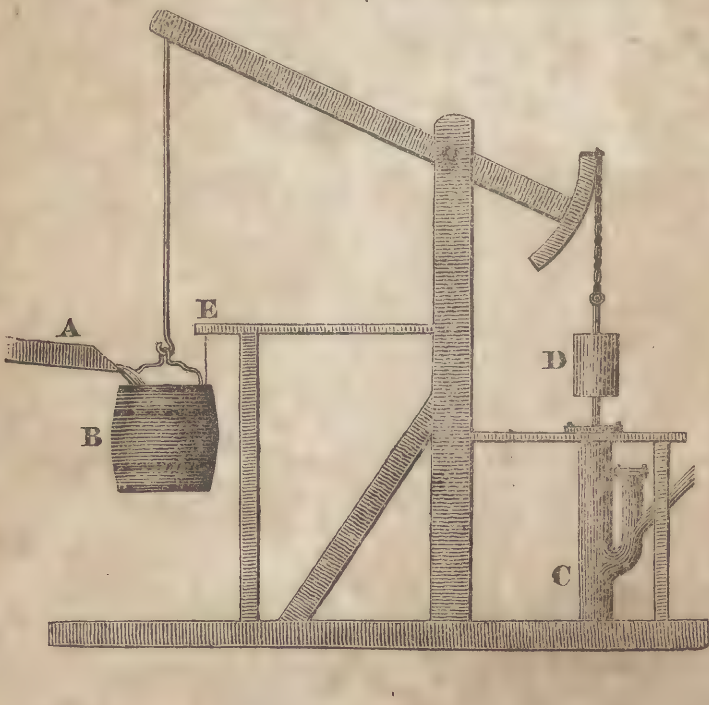
Irton Hall, the seat of E. I. Irton, Esq. is situated on an ascent of sixty or sixty-one feet perpendicular height; at the foot of which, at the distance of about one hundred and forty yards from the offices, runs a small stream of water. The object was to raise this to the house for domestic purposes.

To this end, a dam was made at a short distance above, so as to cause a fall of about four feet; and the water was brought by a wooden trough, into which was inserted a piece of two-inch leaden pipe, a part of which is seen at A, fig. 3. The stream of this pipe is so directed, as to run into the bucket B, when the bucket is elevated; but so soon as it begins to descend, the stream flows over it, and goes to supply the wooden trough or well, in which the foot of the forcing pump C stands, of three inches bore.

D, is an iron cylinder attached to the pump rod, which passes through it. It is filled with lead, and weighs about two hundred and forty pounds. This is the power which works the pump, and forces the water through four hundred and twenty feet of inch pipe, from the pump up to the house.

At E, is fixed a cord which, when the bucket comes to within four or five inches of its lowest projection, becomes stretched, and opens a valve in the bottom of it, through which the water empties itself.

I beg leave to add, that an engine, in a great degree similar to this, was erected some years ago by the late James Spedding, esquire, for a lead mine near Keswick, with the addition of a smaller bucket which emptied itself into the larger, near the beginning of its descent, without which addition it was found that the beam



only acquired a vibratory motion, without making a full and effective stroke.

To answer this purpose in a more simple way, I constructed the small engine in such a manner, as to finish its stroke (speaking of the bucket end,) when the beam comes into an horizontal position, or a little below it. By this means, the lever is virtually lengthened in its descent in the proportion of the radius to the cosine, of about thirty degrees, or as seven to six nearly, and consequently, its power is increased in an equal proportion.

It is evident, that the opening of the valve might have been effected, perhaps better, by a projecting pin at the bottom; but I chose to give an exact description of the engine as it stands. It has now been six months in use, and completely answers the purpose intended.

The only artists employed, except the plumber, were a country blacksmith and carpenter; and the whole cost, exclusive of the pump and pipes, did not amount to five pounds."

In another letter, dated Whitehaven, April 28, 1801, Mr. Sarjeant further observes, that the pump requires about eighteen gallons of water in the bucket to raise the counter-weight, and make a fresh stroke in the pump; that it makes three strokes in a minute, and gives about a half gallon into the cistern at each stroke. He adds, "I speak of what it did in the driest part of last summer; when it supplied a large family, together with work people, &c. with water for all purposes, in a situation where none was to be had before, except some bad water from a common pump, which had been since removed. But the above supply being more than sufficient, the machine is occasionally stopped to prevent wear, which is done by merely casting off the string of the bucket valve."

Mr. Fessenden in his Register of Arts, observes, that the simplicity of construction, and the cheapness of this machine, must render it worthy of attention, not only for raising water for domestic purposes, but in many cases it might be turned to account in agriculture, by watering upland fields, gardens, &c.

This engine, although the most simple of any which has fallen within our notice, exhibits but one of a great variety of methods which engineers have adopted for raising a part of a stream of water above its level by force of its fall. Machines for accomplishing the same object, but of a more complicated construction, are described in philosophical journals. The invention of Mr. Close, published in Nicholson's Philosophical Journal, for January, 1802, and analysed by Mr. Nicholson in his Journal for February, the same year, of a hydraulick apparatus, acting by a syphon, Mr. Trevithack's powerful engine for raising water by the pressure of a column, enclosed in a pipe, described in Nicholson's Journal, for March, 1802, improvements on the hydraulick engine of Schemnitz, and that of Mr. Goodwyn by Mr. John Whitley Boswell, likewise described in Mr. Nicholson's Journal, have all the same object. But, after having attentively perused these, we are of opinion that the machine, here described, will be found to possess much the greatest general utility. See Hydraulics.

ENGINE STEAM. See Steam Engine.

ENGRAVING, or Graving as it is generally called, is the cutting lines upon a copper-plate, by means of a steel instrument, called a graver, without the use of aqua fortis.

This was the first way of producing copper-plate prints that was practised, and is still much used in historical subjects, portraits, and in finishing landscapes.

It would be an injustice to our countrymen, if we were not to observe, that this art has arrived to perfection in the United States; specimens of engraving, equal, if not superior to the productions of Europe, have long since been produced. This reflects much honour to the names of a number, whom we could mention.

The tools necessary for this art, are, gravers, a scraper, a burnisher, an oil-stone, a sand-bag, an oil-rubber, and some good charcoal.

The gravers are instruments of tempered steel, fitted into a short wooden handle. They are of two sorts, square and lozenge: the first is used in cutting very broad strokes, the other for fainter and more delicate lines.

The scraper is a three-edged tool, for scraping off the burr raised by the graver. Burnishers are for rubbing down any lines that are too deep, or burnishing out any scratches or holes in the copper: they are of very hard steel, well rounded and polished.

The oil-stone is for whetting the gravers, etching-points, &c.

The sand-bag, or cushion, is for laying the plate upon, for the conveniency of turning it round in any direction.

The oil-rubber and charcoal, are for polishing the plate when necessary.

As great care is required to whet the graver nicely, particularly the belly of it, care must be taken to lay the two angles of the graver which are to be held next

the plate, flat upon the stone, and rub them steadily, till the belly rises gradually above the plate, so as that, when you lay the graver flat upon it, you may just perceive the light under the point; otherwise it will dig into the copper, and then it will be impossible to keep a point, or execute the work with freedom. In order to do this, keep your right arm close to your side, and place the fore-finger of your left hand, upon that part of the graver which lies uppermost on the stone. When this is done, in order to whet the face, place the flat part of the handle, in the hollow of your hand, with the belly of the graver upwards, upon a moderate slope, and rub the extremity, or face, upon the stone, till it has an exceedingly sharp point, which you may try upon your thumb-nail.

When the graver is too hard, as is usually the case, when first bought, and may be known by the frequently breaking of the point, the method of *tempering* it, is as follows: Heat a poker red-hot, and hold the graver upon it, within half an inch of the point, till the steel changes to a light straw-colour; then put the point into oil, to cool; or, hold the graver close to the flame of a candle, till it be of the same colour, and cool it in the tallow; but be careful either way, not to hold it too long, for then it will be too soft; and in that case the point, which will then turn blue, must be tempered again. Be not too hasty in tempering; for sometimes a little whetting will bring it to a good condition, when it is but a little too hard.

To hold the graver, cut off that part of the handle which is upon the same line with the belly, or sharp edge of the graver, making that side flat, that it may be no obstruction.

Hold the handle in the hollow of your hand; and, extending your fore-finger towards the point, let it rest on the back of the graver, that you may guide it flat and parallel with the plate. Take care that your fingers do not interpose between the plate and the graver; for they will hinder you from carrying the graver level with the plate, and from cutting your strokes, so clean as they ought to be.

To lay the design upon the plate, after you have polished it fine and smooth, heat it so that it will melt virgin-wax, with which rub it thinly and equally over, and let it cool. Then the design which you lay on, must be drawn on paper, with a black-lead pencil, and laid upon the plate, with its pencilled side upon the wax; then press it to, and with a burnisher, go over every part of the design, and when you take off the paper, you will find every line which you drew with the black-lead pencil, upon the waxed plate, as if it had been drawn; then with a sharp pointed tool, trace all your design through the wax upon the plate, and you may then take off the wax, and proceed to work.

Let the table, or board you work at, be firm and steady; upon which place your sand-bag with the plate upon it; and, holding the graver as above directed, proceed in the following manner.

For straight strokes, hold your plate firm upon the sand-bag, with your left hand, moving your right hand forwards; leaning lighter where the stroke should be fine, and harder where you would have it broader.

For circular or crooked strokes, hold the graver stedfast, moving your hand or the plate, as you see convenient.

Learn to carry your hand with such dexterity, that you may end your stroke as finely, as you began it; and if you have occasion to make one part deeper or blacker than another, do it by degrees; and that you may do it with greater exactness, take care that your strokes be not too close, nor too wide.

In the course of your work, scrape off the roughness which arises, with your scraper; but be careful, in doing this, not to scratch the plate; and that you may see your work properly as you go on, rub it with the oil rubber, and wipe the plate clean, which will take off the glare of the copper, and shew what you have done to the best advantage.

Any mistakes or scratches in the plate, may be rubbed out with the burnisher, and the part levelled with the scraper, polishing it again afterwards, lightly with the burnisher, or charcoal.

Having thus attained the use of the graver, according to the foregoing rules, you will be able to finish the piece you had etched, by graving up the several parts to the colour required; beginning, as in the etching, with the fainter parts, and advancing gradually with the stronger, till the whole is completed.

The dry point or needle, (so called because not used, till the ground is taken off the plate,) is principally employed in the extremely light parts of water, sky, drapery, architecture, &c.

To prevent any obstruction from too great a degree of light, the use of a sash, made of transparent, or fan paper, pasted on a frame, and placed sloping at a convenient distance between your work and the light, will preserve the sight; and when the sun shines, it cannot possibly be dispensed with.

In order to obviate certain inconveni-

Engraver's Machine.

Fig. 1.

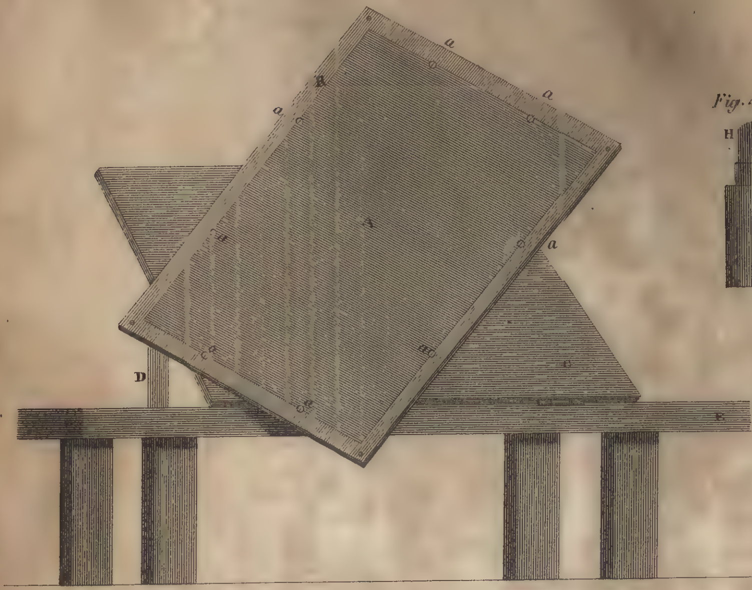


Fig. 4.

Fig. 2.

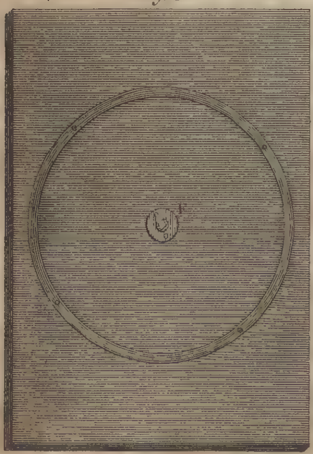
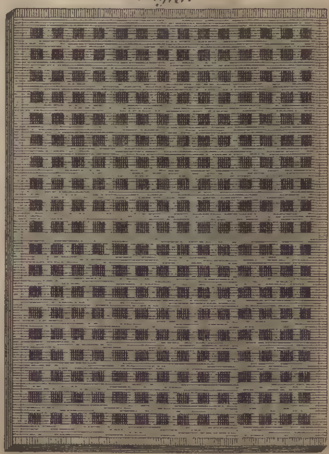


Fig. 3.



H. Anderson sc.

ences, to which engravers are liable, the Abbé Joseph Lorghi, of Monza, has contrived a table, which in the opinion of the most celebrated engravers of our city, is not only very ingenious, but also extremely well calculated for the purpose intended. A gold medal was given to the Abbé for this invention. The first professors of the art in Europe, have approved of it. Without going into particulars, the following description of the plate, will be sufficient.

Plate fig. 1. Represents the whole machine, as it is used.

A. Copper-plate on which the engraving is to be made.

a a a a a a a a. Screws by which the plate is affixed to the moveable board B.

B. The upper or moveable part of the table. It consists of a thin plank, to the bottom of which is united the iron plate, represented in fig. 3.

C. The under-board, which is made to rise and fall at pleasure, in the manner of a pair of hinges; in the middle of it is a pretty thick axis.

D. The foot by which the desk is supported at any required height.

E. The frame of the table.

Fig. 2. The under-board or desk.

F. A circle of iron, through the middle of which protrudes that part of the axis marked H. (In fig. 4.)

Of Mezzotinto Scraping.—This art, which is of late date, is recommended by the amazing ease with which it is executed, especially by those who understand drawing.

Mezzotinto prints are those which have no patching, or strokes of the graver, but whose lights and shades are blended together, and appear like a drawing in Indian-ink. They are different from aqua tinta; but as both resemble Indian-ink, the difference is not easily described: Mezzotinto is applied to portraits and historical subjects; and aqua tinta is used only for landscape and architecture.

The tools necessary for mezzotinto scraping are the grounding-tool, burnishers, and scrapers.

To lay the mezzotinto ground, lay your plate, with a piece of flannel under it, upon your table, hold the grounding-tool in your hand perpendicularly; lean upon it moderately hard, continually rocking your hand in a right line from end to end, till you have wholly covered the plate in one direction: next cross the strokes from side to side, afterwards from corner to corner, working the tool each time all over the plate, in every direction, almost like the points of a compass: taking all possible care not to let the tool cut (in one direction) twice in a place. This done, the plate will be full, or, in other words, all over rough alike, and would, if it were printed, appear completely black.

Having laid the ground, take the scrapings of black chalk, and with a piece of rag rub it over the plate; or you may smoke it with candles, as before directed, for etching.

Now take your drawing, and having rubbed the black with red-chalk dust, mixed with flake-white, proceed to trace it on the plate.

To form the lights and shadows, take a blunt needle, and mark out the outline only; then with a scraper scrape off the lights in every part of the plate, as clean and smooth as possible, in proportion to the strength of the lights in your drawing, taking care not to hurt your outlines.

The use of the burnisher is to soften or rub down the extreme light parts after the scraper is done with; such as the tip of the nose, forehead, linen, &c. which otherwise, when proved, appear rather misty than clear.

Another method used by mezzotinto scrapers, is, to etch the outlines of the original, as also the folds in drapery, making the breadth of the shadows by dots, which having bit to a proper depth with aqua fortis, they take off the ground used in etching, and having laid the mezzotinto ground, proceed to scrape as above.

When your plate is ready for taking a proof or impression, send it to the copper-plate printer, and get it proved. When the proof is dry, touch it with white chalk where it should be lighter, add with black chalk where it should be darker; and when the print is retouched, proceed as before, for the lights; and for the shades use a small grounding-tool, as much as you judge necessary to bring it to a proper colour; and when you have done as much as you think expedient, prove it again; and so proceed to prove and touch till it is entirely to your mind.

Of engraving in Aqua Tinta.—Aqua Tinta is a method of producing prints very much resembling drawings in Indian-ink.

The principle of the process consists in corroding the copper with aqua fortis, in such a manner that an impression from it has the appearance of a tint laid on the paper. This is effected by covering the copper with a powder or some substance which takes a granulated form, so as to prevent the aqua fortis from acting where the particles adhere, and by this means

causes it to corrode the copper partially, and in the interstices only. When these particles are extremely minute and near to each other, the impression from the plate appears to the naked eye exactly like a wash of Indian-ink; but when they are larger, the granulation is more distinct, and as this may be varied at pleasure, it is capable of being adapted with great success, to a variety of purposes and subjects.

This powder, or granulation, is called the *aqua tinta grain*, and there are two general modes of producing it.

We shall first describe what is called the *powder-grain*, because it was the first that was used.

Having etched the outline on a copper-plate, prepared in the usual way by the coppersmith (for which see the article etching), some substance must be finely powdered and sifted, which will melt with heat, and when cold will adhere to the plate, and resist the action of aqua fortis. The substances which have been used for this purpose, either separately or mixed, are *asphaltum, Burgundy-pitch, rosin, gum-copal, gum-mastich*; and in a greater or less degree, all the resins and gum-resins will answer the purpose. Common rosin has been most generally used, and answers tolerably well; though gum-copal makes a grain that resists the aqua fortis better.

The substance intended to be used for the grain, must now be distributed over the plate as equally as possible; and different methods of performing this essential part of the operation have been used by different engravers, and at different times.

The most usual way is to tie up some of the powder in a piece of muslin, and strike it against a piece of stick, held at a considerable height above the plate; by this, the powder that issues falls gently, and settles equally over the plate. Every one must have observed how uniformly hair powder settles upon the furniture after the operation of the hair-dresser. This may afford a hint towards the best mode of performing this part of the process. The powder must fall upon it from a considerable height, and there must be a sufficiently large cloud of the dust formed. The plate being covered equally over with the dust, or powder, the operator is next to proceed to fix it upon the plate, by heating it gently, so as to melt the particles. This may be effected by holding under the plate lighted pieces of brown paper rolled up, and moving them about till every part of the powder is melted; this will be known by its change of colour, which will turn brownish. It must now be suffered to cool, when it may be examined with a magnifier, and if the grains of particles appear to be uniformly distributed, it is ready for the next part of the process.

The design or drawing to be engraved must now be examined, and such parts of it as are perfectly white, are to be remarked. Those corresponding parts of the plate must be covered, or stopped-out as it is called, with turpentine-varnish, diluted with turpentine to a proper consistence to work freely with the pencil, and mixed with lamp-black to give it colour; for if transparent, the touches of the pencil would not be so distinctly seen. The margin of the plate must also be covered with varnish. When the stopping-out is sufficiently dry, a border of wax must be raised round the plate, in the same manner as in etching, and the aqua fortis properly diluted with water poured on. This is called biting-in, and is the part of the process which is most uncertain, and which requires the greatest degree of experience. When the aqua fortis has lain on so long that the plate, when printed, would produce the lightest tint in the drawing, it is poured off, and the plate washed with water, and dried. When it is quite dry, the lightest tints in the drawing are stopped out, and the aqua fortis poured on as before, and the same process is repeated as often as there are tints to be produced in the plate.

Although many plates are etched entirely by this method of stopping-out and biting-in alternately, yet it may easily be conceived, that in general, it would be very difficult to stop round, and leave out all the finishing touches, as also the leaves of trees and many other objects, which it would be impossible to execute with the necessary degree of freedom in this manner.

To overcome this difficulty, another very ingenious process has been invented, by which these touches are laid on the plate with the same ease and expedition as they are in a drawing in Indian-ink. Fine washed whiting is mixed with a little treacle or sugar, and diluted with water in the pencil, so as to work freely, and this is laid on the plate covered with the aqua-tint ground, in the same manner and on the same parts as ink on the drawing. When this is dry, the whole plate is varnished over with a weak and thin varnish of turpentine, asphaltum, or mastich, and then suffered to dry, when the aqua fortis is poured on. The varnish will immediately break in upon the parts where the treacle mixture was laid, and expose all

those places to the action of the acid, while the rest of the plate remains secure. The effect of this will be, that all the touches or places where the treacle was used, will be bit-in, deeper than the rest, and will have all the precision and firmness of touches in Indian-ink.

After the plate is completely bit-in, the bordering-wax is taken off, by heating the plate a little with a lighted piece of paper; and it is then cleared from the ground and varnish, by oil of turpentine, and wiped clean with a rag and a little fine whiting, when it is ready for the printer.

The principal disadvantages of this method of aqua-tinting are, that it is extremely difficult to produce the required degree of coarseness or fineness in the grain, and that plates so engraved do not print many impressions before they are worn out. It is therefore now very seldom used, though it is occasionally of service.

We next proceed to describe the second method of producing the aqua tint ground, which is generally practised. Some resinous substance is dissolved in spirits of wine, as common resin, Burgundy-pitch, or mastich, and this solution is poured all over the plate, which is then held in a slanting direction till the superfluous fluid drains off; and it is laid down to dry, which it does in a few minutes. If the plate be then examined with the magnifier, it will be found that the spirit, in evaporating, has left the resin in a granulated state, or rather, that the latter has cracked in every direction, still adhering firmly to the copper.

A grain is thus produced with the greatest ease, which is extremely regular and beautiful, and much superior for most purposes to that produced by the former method. After the grain is formed, every part of the process is conducted in the same manner as above described.

Having thus given a general idea of the art, we shall mention some particulars necessary to be attended to, in order to ensure success in the operation. The spirits of wine used for the solution, must be highly rectified, and of the best quality. Resin, Burgundy-pitch, and gum-mastich, when dissolved in spirits of wine, produce grains of a different appearance and figure, and are sometimes used separately, and sometimes mixed in different proportions, according to the taste of the artist, some using one substance and some another. In order to produce a coarser or finer grain, it is necessary to use a greater or smaller quantity of resin; and to ascertain the proper proportions: several spare pieces of copper must be provided, on which the liquid may be poured, and the grain examined, before it is applied to the plate to be engraved. After the solution is made, it must stand still and undisturbed for a day or two, till all the impurities of the resin have settled to the bottom, and the fluid is quite pellucid. No other method of freeing it from those impurities has been found to answer; straining it through linen or muslin, only fills it with hairs, which are ruinous to the grain. The room in which the liquid is poured on the plate, must be perfectly still and free from dust, which, whenever it falls on the plate while wet, causes a white spot, which it is impossible to remove without laying the grain a-fresh. The plate must also be previously cleaned, with the greatest possible care, with a rag and whiting, as the smallest stain or particle of grease produces a streak or blemish in the grain. All these attentions are absolutely necessary to produce a tolerably regular grain; and, after every thing that can be done by the most experienced artists, still there is much uncertainty in the process. They are sometimes obliged to lay on the grains several times, before they procure one sufficiently regular. The same proportions of materials do not always produce the same effect, as it depends in some degree on their qualities; and it is even materially altered by the weather. These difficulties are not to be surmounted, but by a great deal of experience; and those who are daily in the habit of practising the art, are frequently liable to the most unaccountable accidents Indeed it is much to be lamented, that so elegant and useful a process should be so extremely delicate and uncertain.

It being necessary to hold the plate in a slanting direction, in order to drain off the superfluous fluid, there will naturally be a greater body of the liquid at the bottom than at the top of the plate. On this account, a grain laid in this way is always coarser at the side of the plate that was held lowermost. The most usual way is, to keep the coarsest side for the foreground, that being generally the part which has the deepest shadows. In large landscapes, sometimes various parts are laid with different grains, according to the nature of the subject.

The finer the grain is, the more nearly does the impression resemble Indian-ink, and the fitter it is for imitating drawings: but very fine grains have several disadvantages; for they are apt to come off before the aqua fortis has lain on long enough to produce the desired depth;

and as the plate is not corroded so deep, it sooner wears out in printing; whereas, coarser grains are firmer, the acid goes deeper, and the plate will throw off a great many more impressions. The reason of all this is evident, when it is considered, that in the fine grains, the particles are small and near each other, and consequently the aqua fortis, which acts laterally as well as downwards, soon undermines the particles, and causes them to come off. If left too long on the plate, the acid would eat away the grain entirely.

On these accounts, therefore, the moderately coarse grains are more sought after, and answer better the purpose of the publisher, than the fine grains which were formerly in use.

Although there are considerable difficulties in laying properly the aqua tint grain, yet the corroding the copper, or biting-in, so as to produce exactly the tint required, is still more precarious and uncertain. All engravers allow that no positive rules can be laid down, by which the success of this process can be secured; nothing but a great deal of experience and attentive observation can enable the artist to do it with any degree of certainty.

There are some hints, however which may be of considerable importance to the person who wishes to attain the practice of this art. It is evident, that the longer the acid remains on the copper, the deeper it bites, and consequently the darker will be the shade in the impression. It may be of some use, therefore, to have several bits of copper laid with aqua tint grounds, of the same kind to be used in the plate, and to let the aqua fortis remain for different lengths of time on each; and then to examine the tints produced in one, two, three, four minutes, or longer. Observations of this kind, frequently repeated, and with different degrees of strength of the acid, will at length assist the judgment, in guessing at the tint which is produced in the plate. A magnifier is also useful to examine the grain, and to observe the depth to which it is bit. It must be observed, that no proof of the plate can be obtained till the whole process is finished. If any part appears to have been bit too dark, it must be burnished down with a steel burnisher; but this requires great delicacy and good management not to make the shade streaky; and as the beauty and durability of the grain is always somewhat injured by it, it should be avoided as much as possible.

Those parts which are not dark enough must have a fresh grain laid over them, and be stopped round with varnish, and subjected again to the aqua fortis. This is called re-biting, and requires peculiar care and attention The plate must be very well cleaned out with turpentine before the grain is laid on, which should be pretty coarse, otherwise it will not lay upon the heights only, as is necessary, in order to produce the same grain. If the new grain is different from the former, it will not be so clear nor so firm, but rotten.

We have now given a general account of the process of engraving in aqua tint, and we believe that no material circumstance has been omitted, that can be communicated without seeing the operation: but after all it must be confessed, that no printed directions whatever, can enable a person to practise it perfectly. Its success depends upon so many niceties, and attention to circumstances apparently trifling, that the person who attempts it must not be surprized, if he does not succeed at first. It is a species of engraving simple and expeditious, if every thing goes on well; but it is very precarious, and the errors which are made, are rectified with great difficulty.

It seems to be adapted chiefly for imitation of sketches, washed drawings, and slight subjects; but does not appear to be at all calculated to produce prints from finished pictures, as it is not susceptible of that accuracy in the balance of tints, necessary for this purpose. Nor does it appear to be suitable for book-plates, as it does not print a sufficient number of impressions. It is therefore not to be put in competition with the other modes of engraving. If confined to those subjects for which it is calculated, it must be allowed to be extremely useful, as it is expeditious, and may be attained with much less trouble, than any other mode of engraving. But even this circumstance is a source of mischief, as it occasions the production of a multitude of prints, that have no other effect, than that of vitiating the public taste.

Engraving in aqua tint, was invented by Le Prince, a French artist, who kept his process a long time secret, and it is said he sold his prints at first as drawings; but he appears to have been acquainted only with the powder-grain, and the common method of stopping-out. The prints which he produced are still some of the finest specimens of the art. Mr. Paul Sandby, was the first who practised it in England, and it was by him communicated to Mr. Jukes. It is now practised very general-

ly all over Europe; and also in the United States.

The following description of an apparatus to prevent the inconvenience which artists experience from the fumes in aqua tinta engraving, may be useful.

In the art of aqua tinta engraving, the artists experience much inconvenience from the quantity of fumes or nitrous gas liberated by the action of the acid upon the copper.

To remedy this the following arrangement, has been proposed by Mr. Cornelius Varley.

Get a frame made of any kind of wood, three or four inches deep, covered with a plate of glass, and open at one side Let the side opposite to this, have a round opening, communicating by means of a common iron pipe, with the ash pit of any little stove or other fire place, shut up from all other access of air, but what must pass through the pipe. Any fumes arising from such a frame, will be carried into the iron pipe, by the current of air, required to maintain combustion in the stove; and will by this means, be carried up the chimney, wherever it may be, instead of being allowed to fly about the apartment. The pipe may be very conveniently used, by carrying it down through the table to the floor, and thence along to the chimney, wherever it may be; and when the frame is not wanted, the pipe at any one of the joinings, may be made to answer the purpose of a hinge, by which to turn up the frame against the wall, where it may be secured while out of use, by a button, or any similar contrivance.

ENGRAVING ON WOOD. Engraving on wood is a process exactly the reverse to engraving on copper. In the latter, the strokes to be printed are sunk, or cut into the copper, and a rolling-press is used for printing it; but in engraving on wood, all the wood is cut away, except the lines to be printed, which are left standing up like types, and the mode of printing is the same, as that used in letter-press.

The wood used for this purpose is generally boxwood, which is planed quite smooth. The design is then drawn upon the wood itself with black-lead, and all the wood is cut away with gravers and other proper tools, except the lines that are drawn. Or sometimes the design is drawn upon paper, and pasted upon the wood, which is cut as before. This art, is of considerable difficulty, and there are very few who practise it. It is, however, useful for books, as the printing of it is cheaper than that of copper-plates. It cannot be applied equally well to all the purposes to which copper-plate engraving is applicable.

The art of engraving on wood, has been successfully practised in the United States, and particularly in Philadelphia.

ENGRAVING or ETCHING on GLASS. Glass resists the action of all the acids, except the fluoric acid. By this, however, it is corroded in the same manner, as copper is by aqua fortis; and plates of glass may be engraved, in the same manner as copper.

There are several methods of performing this. We shall first describe the mode of etching, by means of the fluoric acid in the *state of gas*. Having covered over the glass to be etched with a thin coat of virgin-wax (which is only common bees-wax bleached white,) draw the design upon it, in the same manner as in etching on copper. Then take some *fluor spar*, commonly called *Derbyshire spar* pound it fine, and put it into a leaden vessel, pouring some sulphuric acid over it. Place the glass with the etched side lowermost over this vessel, two or three inches above it. Apply a gentle heat to the leaden vessel; this will cause the acid to act upon the fluor spar, and disengage the gas, which will corrode the glass. When it is sufficiently corroded, remove the wax by oil of turpentine.

This etching may be also performed by raising a margin of bordering-wax all round the glass, in the same manner as on copper, and pouring on the liquid fluoric acid, which acts upon the glass.

A third method of etching on glass is as follows: Having put the wax on the glass, draw your design, and raise a margin all round it. Then put pounded fluor spar with some sulphuric acid, diluted with water, upon the glass. The sulphuric acid will disengage the fluoric, which will be absorbed by the water, and corrode the glass.

By following the processes above mentioned, we have succeeded in etching on glass, bottles, chemical apparatus, &c.

This art is also practised in the United States. The principles of the process consists, 1st, in the disengagement of the fluoric acid from the spar, which is effected in consequence of the sulphuric acid, having a greater affinity for the lime, of the fluate of lime, (fluor spar;) and 2ndly, the action of the fluoric acid gas, on the silica of the glass. Owing to the action of this acid on glass, glass retorts can never be used; but for the purpose of distilling the acid, either leaden or block tin retorts are employed. The application

of fluoric acid to etching, has been improved by Mr. Aikin; an account of the apparatus he employs, may be seen in Tilloch's Philosophical Magazine. The liquid fluoric acid, if it be preferred, must be kept in a bottle, lined with wax, or in a leaden or block tin vessel.

EPSOM SALT.—This is a magnesian salt, which consists of sulphuric acid and magnesia, called sulphate of magnesia, and is used for the preparation of magnesia. It is obtained by evaporating the waters of Epsom; hence its name. It is rarely used in medicine, though it is cathartic; but is used, more generally, for the purpose before mentioned. To obtain magnesia, the salt is dissolved in water, and half its weight of potash is added, which, by combining with the sulphuric acid into sulphate of potash, precipitates the earth in the form of a white powder. This powder is collected, washed, and dried, and then forms the magnesia of the shops. See MAGNESIA.

ESSENTIAL OILS. See OILS, ESSENTIAL; also DISTILLING.

ESSENTIAL OIL VARNISHES. See VARNISH.

ETCHING, is a manner of engraving on copper, in which the lines or strokes, instead of being cut with a tool or graver, are corroded in, with aqua fortis.

It is a much later invention than the art of engraving, by cutting the lines on the copper, and has many advantages over it for some purposes, though it cannot supersede the use of the graver entirely, as there are many things that cannot be etched so well as they can be graved.

In almost all the engravings on copper, that are executed in the stroke manner, etching and graving are combined, the plate being generally begun by etching, and finished with the graver. Landscapes, architecture, and machinery, are the subjects that receive most assistance from the art of etching; for it is not so applicable to portraits and historical designs.

We shall first describe the various instruments and materials used in the art.

Copper-plates may be had ready prepared at the coppersmiths, by those who reside in large towns; but, when this cannot be had, procure a piece of pretty thick sheet-copper from a brazier, rather larger than your drawing, and let him planish it well; then take a piece of pumice-stone, and with water rub it all one way, till the surface is as smooth and level as it can be made by that means: a piece of charcoal is next used with water, for polishing it still farther, and removing the deep scratches made by the pumice-stone; and it is then finished with a piece of charcoal of a finer grain, with a little oil.

Etching-points, or *needles*, are pointed instruments of steel, about an inch long, fixed in handles of hard wood, about six inches in length, and of the size of a goose-quill. They should be well tempered, and very accurately fixed in the centre of the handle. They must be brought to an accurately conical point, by rubbing upon an *oil-stone*, with which it is also very necessary to be provided. Several of these points will be necessary.

A *parallel-ruler* is necessary for drawing parallel straight lines with. This is best when faced with brass, as it is not then so liable to be bruised by accident.

Compasses are useful for striking circles and measuring distances.

Aqua fortis, or what is better, spirits of nitre (nitrous acid), is used for corroding the copper, or *biting*-in, as it is called. This must be kept in a bottle with a glass stopple, for its fumes destroy corks. A stopple made of wax will serve as a substitute, or a cork well covered with wax.

Bordering-wax, for surrounding the margin of the copper-plate, when the aqua fortis is pouring on. This may be bought ready prepared, but it may be made as follows.

Take one-third of bees-wax, to two-thirds of pitch; melt them in an iron ladle, and pour them, when melted, into water, lukewarm; then mould it with your hand till it is thoroughly incorporated, and all the water squeezed out. Form it into rolls of convenient size.

Turpentine-varnish is used for covering the copper-plate with, in any part where you do not wish the aqua fortis to bite. This may be diluted to a proper consistency with turpentine, and mixed with lamp-black, that it may be seen better when laid upon the plate.

Etching-ground, is used for covering the plate all over with, previous to drawing the lines on it with the needles. It is prepared in the following manner.

Take of virgin-wax and asphaltum, each twenty ounces, of black-pitch and Burgundy-pitch, each half an ounce; melt the wax and pitch in a new earthenware glazed pipkin, and add to them, by degrees, the asphaltum, finely powdered. Let the whole boil till such time as that, by taking a drop upon a plate, it will break when it is cold, on bending it double two or three times between the fingers. The varnish being then enough boiled, must be taken off from the fire, and letting it cool a little, must be poured into warm water, that it may work the

more easily with the hands, so as to form into balls for use.

It must be observed, first, that the fire be not too violent, for fear of burning the ingredients; a slight simmering will be sufficient; secondly, that while the asphaltum is putting in, and even after it is mixed with them, the ingredients should be stirred continually with a spatula; and thirdly, that the water into which this composition is thrown, should be nearly of the same degree of warmth with it, to prevent a kind of cracking, which happens when the water is too cold.

The varnish ought always to be harder in summer than winter, and it will become so, if it be suffered to boil longer, or if a greater proportion of the asphaltum be used. The experiment above mentioned, of the drop suffered to cool, will determine the degree of hardness or softness, that may be suitable to the season when it is used.

To lay the ground for etching, proceed in the following manner: Having cleaned the copper-plate with some fine whiting and a linen rag, to free it from all grease, fix a hand-vice to some part of it, where no work is intended to be, to serve as a handle for managing it by, when warm. Roll up some coarse brown paper, and light one end; then hold the back of the plate over the burning paper, moving it about until every part of it is equally heated, so as to melt the etching-ground, which should be wrapped up in a bit of taffety, to prevent any dirt that may happen to be among it, from mixing with what is melted upon the plate. If the plate be large, it will be best to heat it over a chafing-dish with some clear coals. It must be heated just sufficient to melt the ground, but not so much as to burn it. When a sufficient quantity of the etching-ground has been rubbed upon the plate, it must be dabbed, or beat gently, while the plate is hot, with a small dabber made of cotton, wrapped up in a piece of taffety; by which operation, the ground is distributed more equally over the plate, than it could be by any other means.

When the plate is thus uniformly and thinly covered with the varnish, it must be blackened by smoking it with a wax-taper. For this purpose, twist together three or four pieces of wax-taper, to make a larger flame, and while the plate is still warm, hold it with the varnished side downwards, and move the smoky part of the lighted taper over its surface, till it is made almost quite black; taking care not to let the wick touch the varnish, and that the latter get no smear or stain. In laying the etching-ground, great care must be taken that no particles of dust or dirt of any kind settle upon it, as that would be found very troublesome in etching; the room, therefore, in which it is laid, should be as still as possible, and free from dust. The ground being now laid, and suffered to cool, the next operation is to transfer the design to the plate.

For this purpose, a tracing on oiled paper, must now be made, from the design to be etched, with pen and ink, having a very small quantity of ox's gall mixed with it, to make the oiled paper take it; also a piece of thin paper, of the same size, must be rubbed over with red chalk, powdered, by means of some cotton. Then laying the red chalked paper, with its chalked side next the ground, on the plate, put the tracing over it, and fasten them both together, and to the plate, by a little bit of the bordering-wax.

When all this is prepared, take a blunt etching needle, and go gently all over the lines in the tracing; by which means the chalked paper will be pressed against the ground, and the lines of the tracing will be transferred to the ground: on taking off the papers, they will be seen distinctly.

The plate is now prepared for drawing through the lines which have been marked upon the ground. For this, the etching-points or needles are employed, leaning hard or lightly, according to the degree of strength required in the lines. Points of different sizes and forms are also used, for making lines of different thicknesses, though commonly, this is effected by the biting-in with the aqua fortis.

A margin, or border of wax, must now be formed all round the plate, to hold the aqua fortis when it is poured on. To do this, the bordering-wax already described, must be put into lukewarm water to soften it, and render it easily worked by the hand. When sufficiently pliable, it must be drawn out into long rolls, and put round the edges of the plate, pressing it down firm, and forming it with the fingers into a neat wall or margin. A spout must be formed in one corner, to pour off the aqua fortis by, afterwards.

The nitrous acid (spirits of nitre) is now to be diluted with four or five times as much water, or more (according as you wish the plate to be bit quick or slow), and poured upon the plate. In a few minutes, minute bubbles of air will be seen filling all the lines that have been drawn on the copper, which are to be removed by a feather; and the plate must be now and then *swept*, as it is called, or kept free from air-bubbles. By the more or less

rapid production of these bubbles, you judge of the rapidity with which the acid acts upon the copper. The biting-in of the plate, is the most uncertain part of the process, and nothing but very great experience can enable any one to tell when the plate is bit enough, as you cannot easily see the thickness and depth of the line till the ground is taken off.

When you judge, from the time the acid has been on, and the rapidity of the biting, that those lines which you wish to be the faintest, are as deep as you wish, you pour off the aqua fortis by the spout, wash the plate with water, and dry it, by blowing with bellows, or by the fire, taking care not to melt the ground.

Those lines that are not intended to be bit any deeper, must now be stopped up with turpentine-varnish, mixed with a little lamp-black, and laid on with a camel's-hair pencil; and when this is thoroughly dry, the aqua fortis may be poured on again, to bite the other lines that are required to be deeper.

This process of stopping-out and biting-in, is to be repeated as often as there are to be lines of different degrees of thickness, taking care not to make any mistake in stopping-out wrong lines.

It is also necessary to be particularly careful to stop-out with the varnish, those parts from which the ground may happen to have come off by the action of the acid, otherwise you will have parts bit that were not intended, which is called *foul-biting*.

When the biting-in is quite finished, the next operation is to remove the bordering-wax and the ground, in order that you may see what success you have had; for till then, this cannot be known exactly.

To take off the bordering-wax, the plate must be heated by a piece of lighted paper, which softens the wax in contact with the plate, and occasions it to come off quite clean.

Oil of turpentine is now poured upon the ground, and the plate is rubbed with a bit of linen rag, which removes all the ground. Lastly, it is cleaned off with whitening.

The success of the etching may now be known; but, it is necessary to get an impression taken upon paper, by a copper-plate printer. This impression is called a *proof*.

If any parts are not bit so deep as were intended, the process may be repeated, provided the lines are not too faintly bit to admit of it. This second biting-in the same lines, is called *re-biting*, and is done as follows: Melt a little of the etching-ground on a square piece of copper, and dab it a little, to get some on the dabber; then, having cleaned out, with whiting, the lines that are to be re-bit, heat the plate gently, and dab it very lightly with the dabber. By this, the parts between the lines will be covered with the ground, but the lines themselves will not be filled up, and consequently will be exposed to the action of the aqua fortis. This is a very delicate process, and must be performed with great care. The rest of the plate must now be varnished over, the bordering wax put on again, and the biting repeated in the same manner, as at first.

If any part should be bit too deep, it is more difficult to recover it, or make it fainter: this is generally done by burnishing the part down, or rubbing it with a piece of charcoal. This will make the lines shallower, and cause them not to print so black.

Should any small parts of the lines have missed altogether in the biting, they may be cut with the graver; which is also sometimes employed to cross the lines of the etching, and thus to work up a more finished effect.

Dry-pointing, as it is called, is another method employed for softening the harsh effects usually apparent in an etching. This is done by cutting with the etching-point upon the copper, without any ground or varnish. This does not make a very deep line, and is used for covering the light, where very delicate tints and soft shadows are wanting.

By varying these processes of etching, graving, and dry-pointing, as is thought necessary, the plate is worked up to the full effect intended; and it is then sent to the *writing engraver*, to grave what letters may be required to be put upon it.

The etching upon sword or knife blades is given in the Laboratory, as follow:

To prepare the Etch-water. Take mercury and aqua-fortis, put them together into a glass, till the mercury is dissolved, and it is fit for use.

To make the Ground. Take three ounces of red lead, one ounce of white lead, half an ounce of chalk, all finely pounded; grind these together with varnish, and anoint your iron; let it dry in the sun, or before a slow fire, and with a pointed steel, or needle, draw or write on it what you please; and then etch it with the above prepared water.

Another Water to etch with. Take two ounces of verdigrise, one ounce of burnt alum, and one ounce of dissolved salt: boil this mixture in one quart of vinegar, till it is half boiled away; and when you are ready to etch, warm, and

pour it with a spoon, or glass cup, over your work; hold it over the fire to keep it warm, and repeat this till you find it etched deep enough.

To etch 100 *or more Knife Blades at once.* Grind red lead with linseed oil, or varnish; with this wipe your blades all over, and let them dry well, and harden: then write or draw, with a pointed bodkin, whatever you will: then put them at some distance from each other, into a glass or well glazed pot or pan; dissolve some vitriol in hot water, pour it over the blades, and lute the glass or pot; set it over a gentle coal-fire; let it boil for some time, and then let it cool; then take your blades, out; scrape the red lead off, and you will find the etching to your satisfaction.

To make Blue Letters on Sword-blades. Take the blade; hold it over a charcoal fire till it is blue; then, with oil colours, write what letters you will upon the blade, and let them dry; when dry, take good strong vinegar; make it warm, and pour it all over the blade; this will take off the blue colour; then wet your oil colour with fresh water, and it will come off easily, and the letters drawn therewith remain blue.

ETCHING, on Stone. A method of etching on calcareous substances, which may be termed a chemical mode of multiplying hatched drawings, has also been recently discovered in England, or recently imported from Germany; and some very spirited sketchy etchings have been executed in this way by the president West, and Messrs. Fuseli, Cosway, Barry, and some other members of the Royal Academy. Messrs. Corbould Stubbs, and C. Heath are also among those who have successfully practised this new art. The materials were supplied by a gentleman not now in England: the knowledge of the exact proportions of the ingredients of which they consisted, was not imparted to those who made use of them, neither is it believed to have been imparted to any one else; but the materials themselves being known, the proportions may presumptively be ascertained by a little experience.

The stone was of a species resembling that fine-grained stone, of a yellowish colour, which is found in large quantities in the neighbourhood of Bath, and is called Bath stone. The etchings were of two kinds; those performed with a crayon, and those performed with pen and ink. The crayon was a mixture of white wax and lampblack, with a small quantity of shell-lac. The ink consisted of shell-lac, borax, and water; and the stones which received the crayons, were ground to a surface somewhat less smooth than those which were prepared for the reception of the ink.

The method of etching is merely drawing on the stone with these materials. The mystery, or secret, which any chemist would easily develope, resides in the manner of printing these drawings, and is simply as follows.

The ink is to be prepared as printer's ink is commonly prepared, namely, ground up with oil; and the paper, which is to receive the impression, must be damped in the usual manner. The etched stone is then to be wetted by immersion in water; when it is taken out, and while it is still wet, the ink being carefully applied on its surface, without violent friction, by means of a printer's ball, (such as is used in letter-press printing,) will be found to adhere only where the stone has been hatched by the artist, with the crayon or ink, the antipathy of oil to water effectually preventing it from sticking any where else. The paper is now to be placed as in letter-press printing, and a pressure, which need not be very violent, applied either by means of a roller, passed over the back of the paper, or otherwise, a blanket of finer woollen cloth being interposed between the roller and paper.

Etching on stone has been practised in this city; but no progress, with respect to its use, has yet been made.

ETCHING, *on Glass.* See ENGRAVING, *on Glass.*

EXTRACT. This is nothing more than the inspissated juice, or decoction, of vegetables. Thus, *liquorice ball* is the extract of liquorice wood, prepared by making a decoction of the wood, and evaporating it to a solid or hard consistence. Extractive matter, in the language of chemists, is a peculiar substance, supposed to be of the immediate materials of vegetables. According as water, spirit, or alcohol is employed to extract the virtues, or particular parts of vegetables, the extract obtained from the decoction, or infusion, is either a watery or spirituous one; hence, in the language of chemistry, such extracts as are obtained by water are principally *gummy*, or, properly, extractive matter; and such as are produced by the use of alcohol, are principally resinous. Thus we have the extract of bark, and the resin of bark, formed in this manner. The use of diluted alcohol, or spirit, forms an extract which contains both a gum and a resin; such extracts are called gum-resins.

The colouring matter of vegetables resides in a gum, a resin, or other

principle; and frequently to obtain it, either water, water and alcohol, or alcohol alone, is necessary, as the menstruum. Considering either one or the other, or that extract itself forms a great portion of the colouring matter of vegetables, in order to apply the colouring matter to stuffs, a proper solvent should be used; and a particular mordant, suited to the stuff and the colour, is indispensably necessary. See DYEING.

Thus, if a solution of alum be added to any extract dissolved in water, a copious coloured precipitate is formed, insoluble in water, and consisting of extract or colouring matter, intimately combined with alumine, whilst the supernatent fluid is rendered nearly colourless. Some of the metallic salts have also this effect; by the metallic oxyd combining with the colouring matter.

F.

FALLOWING of Land. See AGRICULTURE.

FARMING, System of. See AGRICULTURE.

FARRIERY. *The art and profession of the farrier, or farriery*, which has comprehended from the earliest to the present period, the medical and surgical care of the horse, as well as that of manufacturing and fitting him with shoes. These mechanics, as labourers of iron, were originally termed ferriers, from the latin word *ferrum*, iron, and their craft ferriery.—This term remains yet in general use, to its fullest extent, and not inaptly; since, notwithstanding the laudable attempts of many enlightened men, at various periods, the Blacksmiths in America form a very large majority of horse surgeons, and physicians. Nor is this defect peculiar to this country, but prevails in a great degree throughout Europe. The term Veterinary, was originally used by the Latins, (*Vegetius*) and has a more extensive import than our farriery, comprehending the care, both in health, and in a state of disease, of all those animals, domesticated for the laborious service, or food of man. We have chosen to treat the subjects, separately; and having already under the head of Animals Domestic, given an account of the diseases incident to those of other species, with the best mode of cure; we proceed now to the horse;—and, as our limits will not admit of a treatise on the *anatomy* of this useful animal, we are obliged to content ourselves with a concise treatise on the diseases to which he is subject, and of the mode of cure, adopted by the best Veterinarians. Our work being in the form of a dictionary, we shall pursue this plan, and give the diseases in their alphabetic order, as preferable to any other, viz.

Of Abscess.—The treatment of an abscess consists either in resolving it by absorption, or evacuating the matter. The first is the most preferable method, and should always be attempted in the incipient state of abscess, when there is probability of success. The most effectual means for promoting resolution by absorption, are, viz. general bleeding, with a view to lessen the inflammatory action of the system; topical applications to the affected part, such as scarifying, bleeding with leeches, and cold applications, such as solutions of sugar of lead, with water, vinegar, &c. purgatives and clysters, should also be employed; and the horse should be kept on low diet, and all warm applications to be abstained from, as they tend to promote suppuration.

These remedies, when used sufficiently early, will, in general, succeed in discussing an incipient abscess; but should they fail, and the abscess be advanced in size, and the formation of pus; then the contents must be evacuated, and the treatment changed to the direct opposite of what we have recommended for resolving the abscess by absorption. Accordingly, general and local bleedings, are to be avoided; no purgatives should be given, and the patient's strength ought to be supported, as much as possible, with full and nourishing food, to enable it to sustain the loss it is about to suffer. The matter also should be evacuated by a small opening made in the most depending part of the abscess; and not continued from end to end, as was formerly the practice; and, in consequence of which, great irritation was induced, and the pa-

tient sometimes destroyed. And should the abscess be very large, it will be more adviseable to evacuate the matter by degrees, allowing the small orifice to close, and the abscess to fill again, and thus to repeat the evacuation till it be wholly emptied, than to discharge all the matter at once, by which great irritation and danger may be brought on.

Of the Apoplexy, or Staggers.—The *Staggers* is a disease of the brain, arising from an unusual determination of blood to the vessels of this organ, by which its operations become greatly disturbed. It is mostly producted from full feeding, and too little exercise: but it may also take place from an accumulation of water in the ventricles of the brain. Its symptoms are at first drowsiness, the horse being much disposed to sleep, dulness and heaviness of the eyes, loss of appetite, and costiveness, with full and slow pulse. The disease is now termed the sleeping staggers; but, if the proper treatment for its removal be omitted at this stage, an inflammation of the brain ensues, the horse becomes delirious, he plunges violently, falls down as if exhausted, and again starts up with wildness; and now the disease is distinguished by the term mad-staggers, and generally terminates in death. It should here, however, be observed, that the latter disease is not always preceded by the former, it being sometimes the primary one affecting the animal.

As the staggers is, in general, the effect of a plethora, or too great a fullness of blood in the system, bleeding largely is necessarily the most efficacious remedy. When this is done early in the disease, a cure is often effected; but, if the symptoms should not abate in ten or twelve hours, the operation should be again had recourse to. One of the following purgative draughts should also be given; and, with a view to divert the blood from the head, a rowel may be placed under the jaw. This treatment will, most commonly, be effectual; but, should it otherwise happen, and that the delirious or mad-staggers succeed, opening the temporal arteries, and allowing them to bleed copiously, and also blistering the head, are the most likely means to produce benefit.

Purgative Draught, No. 1—Barbadoes Aloes, 7 dr. Castile Soap, 2 dr. Water, 1 pint. Mix for one draught.

Purgative No. 2—Aloes, 6 drachms. Myrrh and Ginger of each, 2 dr. Castile Soap, 3 dr. Simple Mint Water, 1 pint. Mix for one dose.

The operation of these purges may be assisted by a glyster. Should this not succeed in relieving the animal, it will be adviseable to have recourse to one of the two following formulæ.

No. 1—Fœtid Spirit of Ammonia, 1 oz. Camphor 1 dr. Mint Water, 1 pint. Mix for one dose.

No. 2—Spirits of Hartshorn, 1 oz. Powdered Valerian 6 dr. Mint Water, 1 pint. Mix for one dose.

Of Inflammation of the Bladder.—The bladder is liable to have its internal mucous coat generally inflamed, which sometimes terminates fatally. When this disease exists, the bladder is incessantly evacuating the urine, owing to the irritation produced by the want of the mucous secretion, which is now suspended, and which before protected the sensible membrane of the bladder from the stimulus of that fluid.

The cure of this disease consists in bleeding the animal; fomenting the parts contiguous to the inflamed bladder; injecting into this organ warm water; also throwing this fluid up the rectum, and keeping the animal at rest, and warmly clothed. Diuretics should be particularly abstained from, lest, by passing into the bladder, they may continue or augment the disease.

Of Palsy of the Bladder.—The fundus of the bladder is sometimes deprived of its power of contraction, owing to injuries or fracture of the spine, in consequence of which, the spinal marrow being pressed upon, and the nerves going from it losing their capability of sensation, and of exciting voluntary motion, the parts to which these nerves are distributed are necessarily rendered insensible and motionless. This is the case in palsy of the bladder; this organ is no longer under the control of the will, nor does the urine it contains excite any degree of irritation; its sides remain distended with the contents, nor can these be evacuated but by the assistance of the catheter.

A cure can therefore be expected only by first removing the cause; and as fractures of any consequence in the spine of the horse, generally and speedily end fatally, it is almost useless to attend minutely to the affection of the bladder. The urine may occasionally be drawn off by means of a catheter; but the original injury should be the principal object of reparation. This disease is liable to be mistaken for inflammation of the neck of the bladder, as in both these affections, on urine being passed, the bladder continues alike distended; but it may be distinguished from the latter disease, first, by the circumstance of some injury having happened to the spine of the horse; and

secondly, by the ease with which the catheter can be introduced through the neck into the bladder, and which is more difficult to be accomplished in inflammation of that part.

Of Inflammation of the Neck of the Bladder.—This disease is frequent in the horse, but it scarcely ever is met with in mares, owing to the shortness and greater capacity of the female urethra, and which would require an extraordinary degree of inflammation so to close up the orifice of the bladder as to prevent the flowing of its contents.

When this disease is present in the horse, scarcely any urine is voided, and on examination, the bladder will be found distended with this fluid; for now the neck of the bladder being in full contraction from the inflammatory action which is going on, the passage from that organ is nearly obstructed. But as we before observed, care should be taken that this disease be not mistaken for palsy of the fundus of the bladder, and which may be discriminated in the manner mentioned when speaking of the palsy of that organ. And that it may not be confounded with palsy of the neck of the bladder, in which disease the urine passes in drops, the state of the bladder should be ascertained; when, if found to be distended, inflammation of its neck may be concluded upon as the existing disorder.

The treatment of this disease requires much management and nicety, and presents two principal objects for accomplishment, viz. first, the evacuation of the urine from the over-distended bladder; and, secondly, the suppression of the inflammation in the neck of that organ, causing the obstruction. The means to be employed for effecting the latter purpose being similar, whether the disease exists in a horse or mare, we shall describe them first:—Bleeding should be immediately used, as in other inflammatory cases, and for the same purpose, viz. to lessen the action of the blood-vessels, and prevent the accumulation of blood in the diseased part. Fomentations ought also to be employed, and warm water should be frequently injected into the rectum. The animal, at the same time, should be kept warmly clothed, and at rest, and should have half a pint of castor oil administered to him, to obviate costiveness.

Now, to evacuate the urine, which is a principal point to gain in this disease, as it greatly relieves the affected organ, and also the animal, the following methods should be employed. If the patient be a mare, which we have said is rarely the case, less difficulty occurs in drawing off the obstructed urine, and this may be accomplished by introducing a catheter gently through the urethra into the bladder; but if this mode fail, it will then be necessary to puncture the bladder; which should be done with a small trochar entered through the vagina, contiguous to the urinary passage. The operation of evacuating the contents of the male bladder will be attended with more difficulty, owing to the greater length and narrowness, and also the curvature of the urethra in the horse; which circumstances render the introduction of an instrument into the bladder through this long, narrow, and crooked canal, difficult to be performed. Hence it will be necessary, first to introduce a catheter of gum elastic, which will pass through all the crooked and winding parts of the passage.

This operation being certainly attended with far less danger than puncturing the bladder, should therefore be preferred; but when it is necessary to perform the latter operation, the trochar should be made to penetrate, either near to the pubis, for the purpose of avoiding an opening into the cavity of the abdomen, or through the rectum, about an inch or little more up that intestine. It will scarcely be necessary to observe, that, in all these cases, the means must also be used for abating and suppressing the inflammation, which is the cause of the obstruction, as already directed.

Of Botts.—The stomach of the horse, from being partly insensible, is therefore incapable of sympathizing with the other parts of the frame, as in the human subject; and, for the same reason, it is seldom liable to disease. It is, however, sometimes disordered by an accumulation of worms, termed botts, which fasten on the insensible membrane lining the stomach, by two dense, sharp hooks, and which at times, will detach themselves spontaneously.

Those worms are hatched by the warmth of the stomach, from eggs deposited by the horse-fly in the summer season, and which the horse, in biting his hair, on which these eggs are laid, licks up and swallows. They are to be found in most horses, and particularly at a certain time of the year, and in general are not hurtful; but they sometimes increase greatly in number, and, insinuating themselves between the coats of the stomach, greatly indispose this organ, and prevent the horse from thriving. In this case little can be effected by medicines; but the

following aloetic purge will succeed in detaching such of these insects as are already nearly loosened from the stomach.

Purge.—Aloes (Barbadoes) 6 dr. Powdered ginger, 1 dr. Syrup to form one ball.

Of Broken Wind.—A horse labouring under great difficulty of breathing, with heaving flanks, and his expiration being much slower than his inspiration, is said, and not inaptly, to be broken-winded; and hence the inspiration of a broken-winded horse is accomplished in one-third of the time occupied in expiration, which particularly distinguishes this disease from the former one.

A horse, as will be hereafter seen, has a comparatively small stomach, and therefore should be fed often, and with only an apportioned quantity at each time: but when he is forced to fast for any considerable time, and then allowed to eat at pleasure, he generally feeds voraciously, so as to over-distend his stomach; when, if he be smartly exercised, it is extremely probable that broken-wind will be the consequence. From the nature of this disease a cure is not to be expected; and all that can be done is, by regulating the animal's diet, to moderate the inconveniences of the disease: thus to prevent pressure against the lungs, and which must increase the difficulty of breathing, the horse's stomach should be preserved from over distention as much as possible: this is to be effected by giving the horse but little hay or water at a time, and feeding him with nourishing substances which occupy but a small space; such as corn, carrots, beans, &c. and he should be worked generally on an empty stomach.

Broken Knees.—The method of treating this accident is described generally under the article Wounds, being nothing more than a contused and lacerated wound; but as it occurs frequently, and if not skilfully treated, greatly lessens the value of a Horse, it may not be amiss to be more particular on the subject. The first thing to be done is to cleanse the wound perfectly, and if it be at all deep or extensive, or much bruised, a Goulard Poultice (see PHYSIC) is to be applied, by means of the leg of a worsted stocking, taking care to renew it twice a day, that it may be constantly soft and moist; this, in two or three days, will give the wound a healing appearance, and cause a white healthy matter to flow; it may then be discontinued, and the Digestive Ointment applied. Should the matter assume a bad appearance, losing its white colour, becoming thin, and smelling rather offensively, something stronger will be requisite, such as the Detergent Lotion, made hot; and if, after this, the new flesh grows too luxuriantly, rising above the skin, apply the Caustic Powder, and a considerable degree of pressure, by means of a linen roller or bandage, and a bolster of lint. By this treatment the wound will soon heal. But we must not stop here; for unless the swelling is completely removed, and the hair regenerated of its original colour and smoothness, the horse would be considered of very little value. As soon, therefore, as the wound is completely healed, if any swelling is discernable, apply the following liniment, so as to excite a moderate degree of vesication, or blistering, and repeat it after this effect has perfectly subsided. Should the swelling feel hard and callous, and be of considerable size, the strong blister, No. 2 or No. 3, will be preferable.

The Liniment.—Powdered Cantharides, 2 dr. Camphor, ½ oz. Spirit of Wine, 4 oz. Mix them in a bottle, and let it stand in a warm place about a week or ten days, shaking the bottle frequently; then strain through blotting paper, and it is fit for use.

It often happens, after the wound is perfectly healed, that a small scar or mark will be observable, and though the part may be free from any hardness or swelling, the value of the horse will be greatly lessened by this appearance. A variety of ointments have been recommended for promoting the growth of hair on the part, and thereby removing the blemish: the following I have found more effectual than any of them.

Ointment for Broken Knees.—Ointment of Wax, 2 oz. Camphor, 2 dr. Oil of Rosemary, 1 dr. Mix.

The colour of this ointment should be suited to that of contiguous hair, which will so conceal the blemish, that it will not be observed, unless the part is strictly examined; and at the same time, the ointment will cause the hair to grow up gradually, until the mark is completely removed. If the horse is of a bay colour, the legs and knees are generally blackish; in that case mix a little ivory black with the ointment; if a chesnut colour, Armenian bole may be mixed with it.

Bruises.—In recent bruises, fomentations are the most essential remedies. When they are violent, a considerable degree of inflammation may be expected to supervene; it will then be proper to give a laxative ball, and to bleed moderately near the affected part.

If abscesses form in consequence of a bruise, discharging large quantities of

matter, particularly if the matter is of a bad colour and of an offensive smell, the wound also appearing dark-coloured and rotten, indicating approaching mortification; the horse's strength must be supported by allowing him a large quantity of corn, and if he can be made to eat malt, it will be found still more effectual. If the appetite goes off he must be drenched with good water gruel, and strong infusion of malt; it will be necessary also to give the cordial ball (see Physic) for mortification, once or twice a day. Stimulating applications to the part, camphorated spirit and oil of turpentine, equal parts, are of great use.

Should a hard callous swelling remain in consequence of a bruise, the following embrocation is to be well rubbed into the part twice a day, and if it does not succeed in removing it, recourse must be had to a blistering plaster.

Embrocation for Bruises.—No. 1. Camphor, ½ oz. Oil of Turpentine, 1 oz. Soap Liniment, 1½ oz. Mix

No. 2. Tincture of Cantharides, 1 oz. Oil of Origanum, 2 dr. Camphorated Spirit, 6 dr. Mix.

No. 3. Muriate of Ammonia, 1 oz. Distilled Vinegar, 8 oz. Spirit of Wine, 6 oz. Mix.

Canker.—This disease may exist in any of the feet of a horse, but it is more generally found affecting the hind feet of that animal; and, from this circumstance, it is not improbable, that grease may greatly assist in its production; for the extremely offensive and penetrating discharge from the heels of a greased horse, constantly trickling down on the frog, and keeping it moist and soft, must, at length, render it unfit for performing its functions; when contraction, with its consequences, will take place, and both diseases united will terminate in canker.

But the fore-feet are also exposed to grease, contraction, and thrush, and why not be equally affected by canker? To this I answer, the fore-feet certainly are exposed to, and are actually often afflicted with the above diseases, but owing to their bearing more weight, and consequently having greater pressure than the hind feet, the former offer greater resistance to the progress of disease, and consequently rarely run on to canker.

From the nature of thrush, it is evident it must tend to produce canker; for the discharge from the cleft of the frog destroying the hardness, and with it the functions of this organ, the contraction, or cause of disease, becomes aggravated, till the whole of the frog is destroyed; when the destruction extends to the horny sole, and this is likewise rendered soft and rotten; and now the foot is in a state of canker.

This disease, when allowed to proceed too far, is generally incurable, the capability being destroyed with the sensible secreting sole, for producing a new horny sole, and the coffin-bone is now uncovered. To effect a cure, the diseased fungous parts must be cut away, till the blood freely flows; the foot should now be dressed with the following liniment, and the dressings be kept on by means of a bar shoe; nor should it be forgotten that pressure will be one of the best remedies for curing this disease. The dressings ought to be renewed once each day, so as to cut off any fresh fungous matter that may arise.

Strong Liniment.—Oil of turpentine, 1½ oz. Sulphuric acid, ½ oz. Mix slowly tar, 3 oz. Mix.

Mild Liniment.—Chrystallized verde gris powdered, 1 oz. Honey, 2 oz. Powdered bole and alum, of each, ½ oz.

Of the Cataract.—In this disease at first an opaque small point only can be perceived in the centre of the lens by looking into the eye; gradually, but slowly this point of opacity increases, till at length it extends through the whole substance of the lens, causing it to appear white or yellow, and inducing blindness. For the rays of light being wholly obstructed by the lens, now rendered opaque and impenetrable by inflammation, are not permitted to reach the retina, where alone they can make an impression, and, consequently, vision is totally precluded. In the human subject this obstruction is frequently removed, and sight restored, by the extraction or depression of the diseased opaque lens: but this cannot be so well done in the horse, it being extremely difficult to fix his eye so as to perform the operation with success: and further, should the lens be successfully extracted or depressed, and the wounded parts heal, it would be next to an impossibility to keep the proper glasses applied to his eye; without which, his vision must be confused, and rendered more injurious than total blindness.

Catarrh, or Common Cold.—This disease consists in an inflammation of the membrane lining the wind-pipe, and is attended with a cough, discharge at the nostrils, and frequently some fever.

It will be necessary at first to bleed moderately, with the view of keeping down the fever; also give warm bran mashes; blister the throat, keep the horse warmly

clad, purge and give the following fever powder once a day till the horse gets better.

Fever Powder.—Antimonial powder, 3 dr. Camphor, 1 dr. To be mixed for one dose.

Of Chronic Cough.—When recent colds are improperly treated, or neglected, a constant and tiresome cough is apt to be the consequence, which greatly distresses the animal, and remains for a considerable time after the inflammatory affection has subsided.

To remove it, first blister the throat, keep the horse moderately warm, give him regular exercise, and the following ball, once each day, till the horse begins to recover.

Ball.—Tartarized antimony, 1½ dr. Aloes Barbadoes, 1½ dr. Castile soap, 1½ dr. Syrup to form one ball.

Corns, are generally the consequence of bad shoeing, or improper management of the foot, and may therefore be avoided by attending to have that process properly performed—but when they do occur, it is necessary to remove the red part or corn, with a drawing knife, and to apply the shoe so that the tender part may not receive any pressure: when it has been neglected we sometimes find matter formed in this part which often breaks out at the coronet; in this case it is necessary to make an opening for the matter in the angle between the bur and crust. The sore is to be dressed with compound tincture of benzoin, and the cavity to be loosely filled with digestive ointment, which is to be kept in by means of a bur shoe. Tow, dipped in tar and applied to the diseased part previous to healing, is considered useful.

Club.—This term implies a swelling on the back part of the back, which sometimes occasions lameness. Blistering and rest are the only remedies. It is frequently necessary, however, to apply two or three blisters before the swelling is perfectly reduced.

Cutting of the Feet, or Knees.—This is often produced by improper shoeing. Should this be the case, it is obvious that the shoe should be removed, and placed in a proper position. Should it, however, arise, as is sometimes the case, from an improper position or formation of the foot, the toe not being in a line with the point of the shoulder, inclining either inward or outward: In the latter case, we genenerally find that the inner quarter of the hoof is lower than the other, and that the faulty position of the foot depends upon this inequality of the quarters. The remedy, in this case, consists in lowering the outer quarter, and making the inner branch of the shoe thicker than the other. When the toe inclines inward, it renders a horse liable to cut on the inside of the knee, at the lower part of the joint; this is termed the speedy cut, and is considered as a dangerous failing in a horse, the violence of the pain which the blow occasions, sometimes causing him to fall very suddenly.

The remedy for this is to keep the toe as short as possible, that being the part which inflicts the wound; and to alter the improper position of the foot.

Cutting frequently depends upon weakness, or fatigue; and is, therefore, very liable to happen to young horses when ridden hard over heavy ground. The only remedy in this case is, to avoid the cause until the legs acquire more strength, or to protect the wounded part with leather, or a boot, as it is termed. Whenever a horse cuts, it is adviseable to ascertain what part it is that inflicts the wound; and this may often be done by applying tar to the wounded part; this will of course adhere to the part of the hoof or shoe which comes into contact with the wound. Should it be the edge of the shoe, which is seldom the case, the cause may be easily removed by the farrier; whatever part of the hoof it may be, it should be rasped away as much as can be done with safety, and particular attention paid to the position of the other foot, which, if improper, should be improved as much as it can be by shoeing.

Diabetes, or Excess of Staling.—This disease consists in an excessive secretion of urine, and is much more frequent in the human subject than in the horse. It is attended with great heat, and violent thirst; but drinking is found to be productive of mischief, and therefore the use of water and other fluids should be abstained from as much as possible; and as vegetables are known to be favourable to the production of urine, these also should be precluded from use during the continuance of the disease.

The cure of diabetes is effected by confining the patient to the use of animal food; but as the horse has a dislike to feed upon flesh, broths may at first be given; when, after a time, he will be brought to take in solid animal food, and thus the disease will be gradually suppressed.

The following balls have been successfully used in cases of diabetes:

No. 1.

Opium . . . . 1 drachm.
Powdered ginger, ... 2 do.

Yellow Peruvian bark, . . ½ ounce.
Syrup, enough to form the ball for one dose.

No. 2.

Emetic tartar, ... 2 drachms.
Opium, ... 1 do.
To be made into a ball for one dose.

No. 3.

Salt of hartshorn, ... 2 drachms.
Opium, ... ½ do.
Powdered ginger, ... 1 do.
Liquorice powder, ... 3 do.
To be made into a ball for one dose.

Diarrhœa, or Excessive Purging.—The intestines are liable to be excited into an excessive action by the exhibition of too great a quantity of purgative medicine, when constant purging, inflammation, and death, are often the consequence. This more frequently is the case than is admitted or known; for practitioners, who are in the habit of giving large doses of purging medicines to horses, either do not know the danger of such practice, or will not admit it; and after the death of the patient, some other cause than the right one is sure to be assigned for the destruction of the animal. Between four and seven drachms of aloes ought to be the dose for purging a horse; and, if it be necessary to repeat the dose, several days should intervene, lest the effect be rendered too severe. The animal's drink should not be given to him cold, during the operation of the medicine; and his body ought to be clothed, and the stable in which he stands kept moderately warm. With this treatment no danger can accrue, and in a very few days the horse will be fit for work.

But if, on the contrary, a large dose of purging medicine be administered, or a proper treatment not observed during the operation of the medicine, and that excessive purging, with inflammation, have taken place, recourse must be immediately had to the following treatment:—First, then, the horse should be kept warm; and, with the view of removing the irritation with the cause of the disease, starch clysters should be used: by these the inflamed intestine will be fomented, and the remaining aloes washed away; nor ought astringent medicines to be exhibited till this effect be produced. Opium may now be administered in the quantity of half a drachm twice a day; and, at the same time, it should be endeavoured to determine the blood as much as possible to the surface of the body: this is to be effected by employing embrocations of oil of turpentine, by blisters, and even by firing: the animal's extremities, also, should be frequently well rubbed, and his body kept warmly clothed;—and further, the horse should be allowed to remain at perfect rest, lest the action of his intestines may be increased by exercise, and the disease consequently be aggravated. With this treatment the animal may be saved; but it more frequently happens, that either the proper remedies are not employed sufficiently in time, or the inflammation has gone on so rapidly, that mortification and death speedily take place, notwithstanding all the fit means for preventing them were used.

It should be observed, that, in this disease, the cœcum and colon are most generally the seat of inflammation, which, at first, is confined to the mucous membrane of these intestines, but afterwards extends to their muscular and even peritoneal coats.

Inflammation of the Eye.—When the eye is inflamed, it loses part of its beautiful transparency, appearing then as if covered with a film; the lids are partially closed, and the haws become more visible.—Should the inflammation have been brought on by some external injury, and particularly if it is not very considerable, the eye lotion will be sufficient to remove it, but in more violent cases it will be necessary also to bleed moderately and give a laxative ball; by these means inflammation arising from external injury may generally be cured in a short time. The eyes often become inflamed in consequence of cold and fevers, in which cases *the cause* is to be chiefly attended to; when that is removed the inflammation usually ceases.

The most common cause of this complaint is high feeding, without a due proportion of exercise. These cases require great care and attention, for unless proper remedies are employed on the first attack, the disease (though it appears to go off) will be frequently returning, and in all probability eventually produce blindness. The first remedy to be employed on this occasion, is bleeding, and the quantity of blood that is drawn should be proportionate to the violence of the inflammation, and the *condition* of the animal. Should the vessels on the white part of the eye and inner part of the eyelids appear to be distended with blood, great advantage will be derived from scarifying the latter with a lancet. A laxative ball is to be given, and the bowels afterwards kept in a lax state by means of bran mashes. I have found a seton placed immediately under the eye, a very useful remedy; but unless the operation is nicely performed, it frequently leaves an unpleasant mark behind, which would

lead a person, experienced in horses, to suspect that the eye had been diseased, and might therefore diminish the value of the horse.

A shade, so adapted as to preserve the eye from the irritation of dust and light, will be found useful. This kind of inflammation generally comes on rather suddenly, sometimes attacking only one eye, at others both are affected; as there is no apparent cause for this sudden attack of inflammation, the groom very commonly attributes it to seeds or dust having fallen from the rack into the eye, and very little attention is paid to it. Notwithstanding this neglect, the disease frequently goes off, and in some cases its disappearance is nearly as sudden as its attack; in a short time, however, it again appears as unexpectedly as at first, and again perhaps goes off; in this uncertain way it may continue a considerable time, the eyes sometimes appearing transparent, and free from inflammation, at others, watery, inflamed, and opaque on the surface; at length the internal parts of the eye are affected, and a cataract sometimes produced.

It has been supposed, that the diseases of a horse's eye are frequently hereditary, or dependent on some natural defect in the structure. I do not know how far this opinion may be true, but never having seen a case which seemsd to corroborate it, I am not inclined to give it much credit; it is not very improbable, however, that the eyes of some horses may be *naturally* weak, and more liable to become inflamed when exposed to the exciting causes of inflammation, than such as are originally endued with a proper degree of strength; but it appears to me that where this weakness or aptitude to disease exists, it is more frequently the effect of some injury which this tender and delicate organ has sustained, than a defect of *Nature*. When the eye becomes inflamed, it is necessary to enquire into the cause of the inflammation; if it arises from any mechanical injury, and is not very considerable, there is a probability of its being speedily removed, by means of the remedies I have pointed out; but if the inflammation has arisen without any apparent cause, depending, perhaps, upon plethora, or redundancy of blood in the system, there will be some chance of a radical cure, provided the proper remedies are employed sufficiently early; but, if they are neglected at the commencement of the disease, though the inflammation, after some time, appears to go off, and the eye, to a superficial observer, seems to have recovered, yet the disease frequently returns, and ultimately occasions blindness. Should the disease have occurred before, and particularly, if the former attack was violent, there is still less chance of its being removed, and all our remedies may prove ineffectual: in this case, the Alterative No. 3, may be tried. It frequently happens, that when both eyes are inflamed, and a complete cataract forms in one of them, the other becomes perfectly sound and strong. It must be observed, that when a horse has suffered more than once from this disease, and is in low condition, evacuations must not be made too freely; there are few cases, however, where moderate bleeding, and a laxative ball, are not required. With respect to topical applications, or those remedies which are applied immediately to the eye, I must confess that I have not seen much benefit derived from them, except when the inflammation has abated considerably, and there remains an opacity or film on the surface, and then common salt, finely powdered, has often proved useful; but, if the eye has been in this state for some time, and the opacity is very considerable, white vitriol finely powdered and mixed with honey, is a more effectual remedy. Whenever the eyes are weak, or in a state of inflammation, the vapours which arise from foul litter, should be carefully guarded against; indeed, it is by no means an improbable conjecture, that when the eyes are weak, these irritating vapours may often prove the exciting cause of inflammation.

There is a cartilaginous body connected with the eyes of horses, commonly termed the haw. Whenever the eye is drawn into the socket, (which the horse has the power of doing, by means of a muscle that does not exist in the human subject) the haw is forced over the eye, so that when dust happens to adhere to the surface of the eye, he is enabled, by means of this cartilage, to wipe it off; and as light is painful to the animal when the eye is in a state of inflammation, we generally find that organ, on such occasions, drawn more than usual into the socket, and consequently the haw becomes conspicuous on its surface. Farriers in this case, consider the haw as an unnatural excrescence, and the cause of the disease, they frequently therefore cut it off. The once celebrated Mr. Taplin, considered the haw as a preternatural enlargement of the corners of the eye.

Fever.—The fevers of horses bear very little analogy to those of the human body, and require a different treatment. Writers on Farriery have described a great

variety of fevers, but their observations appear to have been drawn from the works of medical authors, and their reasoning seems entirely analogical. I can distinguish only two kinds of fever, the one, an idiopathic or original disease, and therefore properly termed *simple*; the other dependent on internal inflammation, and very justly denominated *symptomatic* fever: for example, if the lungs, bowels, or stomach were inflamed, the whole system would be thrown into disorder, and a symptomatic fever produced; but if a collapse of the perspirable vessels happens to take place, the blood will accumulate in the interior parts of the body, and though inflammation is not produced by it, the unequal distribution of the blood alone will occasion that derangement in the system which constitutes the simple fever. The simple fever does not occur so frequently as the symptomatic, nor is it by any means so formidable in its appearance, yet it is necessary to give it the earliest attention, for unless nature receives timely assistance, she will be sometimes unable to get rid of the load which oppresses her; and the blood will accumulate in the interior part of the body, until inflammation in some of the viscera is produced, and a dangerous disease established. The following are the symptoms of simple fever:—Shivering, succeeded by loss of appetite, dejected appearance, quick pulse, hot mouth, and some degree of debility; the horse is generally costive, and voids his urine with difficulty. Sometimes the disease is accompanied with quickness of breathing, and in a few cases with pain in the bowels, or symptoms of cholic.

As soon as a horse is attacked by this disease, let him be bled freely, and if costiveness is one of the symptoms, give a pint of castor oil, or the oil of olives, and let a glyster of warm water gruel be injected; the fever powder is to be given once in twelve hours, and continued until its diuretic effect becomes considerable. Warm water and mashes are to be frequently offered in small quantities; warm clothing, frequent hand-rubbing, and a liberal allowance of litter are also necessary; and when the fever runs high, it is adviseable to insert rowels about the chest and belly, in order to prevent inflammation from taking place. When the disease appears to be going off, the horse looking more lively, and the appetite returning, let him be led out for a short time in some warm situation, and give now and then a malt mash for the purpose of recovering his strength.

Fever powder.—No. 1. Powdered nitre, 1 oz. Camphor and tartarized antimony, of each 2 dr. Mix for one dose.

No. 2. Powdered nitre, 1 oz. Unwashed calx of antimony, 2 dr. Mix for one dose.

No. 3. Antimonial powder, 3 dr. Camphor, 1 dr. Mix for one dose.

Symptomatic Fever.—The symptomatic fever is generally occcasioned by high feeding, close stables, and a want of proper exercise; sometimes, however, a sudden transition from a cold to a hot temperature is evidently the cause of it; in this respect it is different from the simple fever, which, as before observed, sometimes arises from exposing a horse suddenly to a cold air, when he has been accustomed to a warm stable. Horses that are taken from camp or grass, and put suddenly into warm stables, are extremely liable to those internal inflammations on which symptomatic fever depends, and many thousands fall victims to this kind of treatment.

When a fever is symptomatic, it is not preceded by shivering, nor is it so sudden in its attack as the simple fever; but when it is not subdued by an early application of remedies, the symptoms gradually increase in violence, until they present a very formidable appearance. When the disease however is occasioned by great and long continued exertion, it generally comes on suddenly, and the complaint has a very dangerous appearance in its earliest stage.

The symptomatic fever has many symptoms in common with the simple fever, which are, loss of appetite, quick pulse, dejected appearance, hot mouth, and debility; and, if to these are joined difficulty of breathing, and quick working of the flanks, with coldness of the legs and ears, we may conclude that an inflammation of the lungs is the cause of the fever. If the horse hangs down his head in the manger, or leans back upon his collar with a strong appearance of being drowsy, the eyes appearing watery and inflamed, it is probable that the fever depends upon an accumulation of blood in the vessels of the brain, and that the staggers are approaching: in this case, however, the pulse is not always quickened; sometimes indeed, I have found it unusually slow.

When the symptoms of fever are joined with a yellowness of the eyes and mouth, an inflammation of the liver is indicated. Should an inflammation of the bowels be the cause, the horse is violently griped. An inflammation of the kidneys will also produce fever, and is distinguished by a suppression of urine, and an ina-

bility to bear pressure upon the loins. When inflammation of the bladder is the cause, the horse is frequently staling, voiding only very small quantities of urine, and that with considerable pain. Extensive wounds, and particularly those of joints, will also produce symptomatic fever. Sometimes several of the internal parts are inflamed at the same instant, and indeed, when inflammation has existed for a considerable length of time, it is seldom confined to the organ in which it originated; the disease spreads to other viscera, and when more than one organ is inflamed, the symptoms will generally be complicated; still, however, the essential remedies are the same, that is to say, copious and early bleeding, purging, with rowels and blisters.

The Frog—The frog is a very important part to be known; for, from its good or bad treatment, arises more of the soundness or lameness of horses' feet, than from all the other parts of the foot besides.

Its shape is wedge-like, with a cleft behind: it is composed of a very tough, elastic kind of horn; and is intended to embrace the ground, serving thereby as a stop when the horse is in motion. But, perhaps, its principal use is to keep the heels of the foot expanded, and thereby prevent contraction, which almost always produces lameness, sooner or later. The latter function the frog always performs, while it is in health, and while the heels of the shoe are not allowed to be so thick as to raise it above pressure with the ground: for, by continuing the pressure it receives from the ground to the parts above, these are necessarily expanded laterally, and contraction of the quarters consequently prevented. But if it be cut away, as is frequently and erroneously done in shoeing; or if the heels of the shoe applied to the foot be made too thick, or turned up; in either case the frog being no longer in contact with the ground, there can be no pressure on the foot above; and the quarters of the crust, acted upon by heat, dryness, and perhaps ill-made shoes, necessarily contract; and the bottom of the foot, instead of being nearly a circle in shape, the heels being as far asunder as the toe is from the back of the frog, and which is the true and natural shape of a horse's foot before it is changed by disease and bad shoeing, becomes of partly an oval shape, the distance between the quarters appearing but short, in comparison to that from the toe to the back of the foot.

Of the Grease—This is an inflammation, swelling, and consequent discharge attacking the skin covering the heels of horses: it is brought on by sudden and great changes of temperature, and prevails only in the winter, and most in the wet season. It is never known to attack horses that have not been domesticated; nor does it commence during the time horses are at grass. Horses of a light colour, and particularly where the legs are white, are much more liable to be affected with grease, than are horses with dark coloured legs; and hence it would appear, that the skin bearing light coloured hair, is more delicate and susceptible of injury than skin covered with dark or black hair; and this supposition is further corroborated by seeing that the hair growing from new formed skin, and which is less perfectly organized than the old, is always white: the hind legs also are more frequently greased than the fore legs, owing to their greater distance from the heart, and the circulation in them being consequently weaker.

The change of temperature causing grease, is that which a horse undergoes in being removed from a cold, wet situation, to a warm one: thus, horses taken from grass or camp, and put into warm stables, will often be greased in a very few days afterwards, and particularly if the proper methods be neglected for preventing it; for the heels being mostly wet while the horses were abroad, and consequently subject to bear a greater degree of cold than could have affected them had they remained dry, now that the horses are changed from this cold situation into a warm one, they become inflamed by the increased heat of the stable, and grease is the consequence. To prevent, then, as much as possible, the change of temperature producing grease, the following rules should be observed on removing horses from camp or grass into stables. First, the stable doors and windows should be thrown open during the day, to prevent the too great accumulation of heat, which may afterwards be gradually increased, and the stables ought also to be kept particularly clean: the diet of the horse should be gradually increased; his legs well hand rubbed; and, above all, the horse ought to be regularly exercised each day, which, together with the friction, will promote the circulation in the heels, and promote absorption of any fluid which may be determined to these parts.

The symptoms of grease are, swelling of the legs, attended with heat; soon after this, the inflamed skin, covering the heels, becomes cracked, and an offensive

discharge also takes place. The horse, after having stood still for some time, walks lame at first, owing to the pain he suffers from the tearing asunder the cracks, and which, during his rest, were beginning to unite. The discharge increases in quantity and offensiveness, but does not cause ulceration; the cracks above mentioned, being merely the natural secretion of the skin covering the horse's heels, but increased and changed by the inflammatory action going on in the vessels of the parts.

To cure this disease, it will be necessary to begin with poultices and fomentations of warm water, which should be frequently applied to the affected parts, with the view of removing the inflammation. The following diuretic ball should be occasionally given, to promote absorption; and, with the same intention, exercise ought also to be frequently had recourse to. When the inflammation has subsided, which is often obstinate, and not to be suppressed for four or five weeks, astringent medicines may be used for the purpose of putting an end to the discharge: those mostly used, are blue vitriol and alum, which may be applied alternately, either dissolved in water or finely powdered. Exercise and a diuretic ball, (after proper intervals) may still be continued, and will accelerate the cure; and that the applications may have the better effect, the hair should be kept close cut, and the skin frequently washed with warm water and soap.

Diuretic Ball—Venice turpentine 1 oz. Castile soap 2 oz. Powdered anise-seeds, enough to give consistence—to be divided into three balls.

Sometimes, in grease, the skin becomes of an unusual thickness, from the great quantity of fluid which is determined into it by the inflamed action; and numerous excrescences, termed grapes, from their seeming to grow out in bunches, appear on it: when this is the case, these excrescences should be removed by the actual cautery. Grease is apt to produce another and more dangerous disease, called canker; and for which see title Canker, for the inflammation of grease increases the growth of the hoof; and the frog being, in consequence, raised too far from the ground to admit longer of pressure, and also being in a continual state of moisture from the greasy matter of the heels running down upon it, canker is the consequence.

Of Casting the Hair—Horses cast their hair once a year, some in autumn, but the greatest number in spring; and as there is a great change, attended with some debility, to be observed in the animal during the time he is throwing off the old hair, particular attention should be paid to him at that period.

The weakness he then shews, and his consequent liability to be affected by cold, in all probability arises; the first, from the great proportion of blood which is determined from the other parts of the frame towards the skin for supplying the growth of the new hair; and the second circumstance, or susceptibility of cold, from the unprotected condition of the sensible skin during the interval between casting the old hair and the growth of the new, and which must render it more liable to be affected by the cold.

During this period, then, the horse should be kept more warmly clad than before, and his diet ought to be full and nourishing.

Hide bound.—This term implies a tightness of the skin, which feels as if it were glued to the ribs, the coat having at the same time, a rough unhealthy appearance. This complaint is generally occasioned by worms, or want of attention in the groom; it occurs sometimes, however, without any manifest cause; in such cases give the Alterative Ball, No. 1, every morning, until moderate purging is produced, and if this does not succeed, try the Alterative No. 2, which is to be given every morning for eight or ten days, taking care to assist its operation by warm cloathing, good grooming, and regular exercise. The exercise should not be confined to walking, but may be carried so far as to excite a moderate perspiration. Great care must afterwards be taken that he does not get cold; let him be taken into the stable while warm, and immediately clothed; when the legs and head have been well cleaned, remove the cloth and continue to rub the body with large wisps of clean straw, until it is quite dry.

I cannot forbear mentioning here a remedy that is employed in some parts of Staffordshire for this complaint, as it clearly evinces how necessary it is to rescue this valuable animal from the barbarous and absurd treatment of illiterate Blacksmiths. An account of this operation was sent me by a gentleman who saw it practised a few months ago. "The head and legs of the horse being secured, two men (one on each side) pull the hide from the ribs in about fifty places, with pincers." The proprietor of this unfortunate animal must surely have been destitute of common sense or humanity, to allow an ignorant, unfeeling Farrier to per-

form so cruel and fruitless an operation.

Alterative Balls.—No. 1. Barbadoes Aloes, 1 oz. Castile Soap, 9 dr. Powdered Ginger, 6 dr. Syrup enough to form the mass, to be divided into four doses.

No. 2. Tartarized Antimony, 2½ oz. Powdered Ginger, 1½ oz. Opium, ½ oz. Syrup enough to form the mass, to be divided into eight balls.

Inflammation.—It was supposed by the celebrated Boerhaave, and other Physiologists of his time, that inflammation depended on a viscidity of the blood, which rendered it unfit for circulating in the finer vessels, and that hence arose obstructions, and those appearances by which the disease is characterized. This opinion, however, has obtained very little credit with modern Physiologists, and is now universally rejected, it having been proved, that blood drawn from an animal, labouring under inflammation, is *more fluid*, and *remains fluid longer*, than that which is taken from the same animal when in health.

The most prevailing opinion at present respecting inflammation is, I believe, that it consists in an increased action of the heart and arteries, when *general*; whereby the blood circulates with unusual velocity, throwing the whole system into derangement; and when *local*, or existing in a particular part, the increased action is in like manner, confined to the vessels of that part.

When a part is inflamed, there arises in it an unusual degree of heat, generally attended with considerable tension and swelling; the sensibility and irritability are always increased, and produced by it in parts where it did not before exist; in bones and tendons, for example, scarcely any *sensibility* can be perceived when they are in a state of health; but, when *inflamed*, it is roused to an alarming degree, and the most dangerous consequences may ensue from it.

Inflammation has four modes of termination: the first is termed *resolution*; that is, when the disease, after going a certain length, gradually disappears again; the second, *suppuration*; that is, when matter is formed, or an abscess produced; the third is named *effusion*, which implies an extravasation either of blood, coagulable lymph, or serum: and the fourth, *gangrene* or mortification, by which is meant the death of the inflamed part.

Inflammation of the external parts is generally occasioned by some mechanical injury, such as wounds, bruises, &c. Sometimes, however, it arises from internal inflammation, or symptomatic fever, and is then to be considered as an effort of Nature to cure the internal disease. Thus we sometimes find in fevers, abscesses taking place on the surface of the body, whereby the fever is considerably diminished, and, in general, terminates favourably.

Inflammation is often produced by plethora, or redundancy of blood in the body; in which case it is sometimes general, the whole arterial system having its action increased: this also may be considered as an effort of Nature to get rid of the superfluous blood, and in such cases she must be assisted by copious bleeding. It more commonly happens, however, that the redundant blood is determined to some particular part, occasioning local inflammation; very frequently falling upon some of the internal organs, and the lungs are peculiarly liable to suffer; from this source, indeed, the most dangerous fevers arise. The eyes also are very apt to suffer when a horse becomes plethoric, to which cause, I believe, almost all the diseases of that delicate organ may be attributed.

In the treatment of external inflammation, we should endeavour to bring it to the most favourable termination, that is, *resolution*;—unless when it arises from an effort of Nature to cure some internal disease;—it is then desirable to bring it speedily to suppuration. The remedies to be employed for resolving inflammation, are, local or general bleeding, purgatives, fomentations, poultices, or the Saturnine lotion, made warm; sometimes, indeed, I have seen cold applications used with success, such as Sal Ammoniac dissolved in Vinegar, Goulard, &c.

When inflammation takes place in tendinous parts or joints, the saturnine poultice has been found an useful remedy, and in the latter case I have often found blisters extremely efficacious. As in these cases the inflammation generally proves more troublesome, and as the pain which it occasions is often so considerable as to produce symptomatic fever, it becomes necessary to employ, without loss of time, the most prompt and efficacious means for its reduction; with this view we excite artificial inflammation in the contiguous skin and cellular membrane, which are parts of far less importance in the animal economy, than joints or tendons, and capable of bearing a considerable degree of inflammation, without much inconvenience to the animal: this is done by means of rowels and blisters, and the inflammation thus excited, will tend in a considerable degree to diminish that which is going on

in the more important part. Should we fail in our endeavours to resolve inflammation, it will probably terminate in suppuration; and when it appears that the disease does not abate by the use of the remedies we have recommended, an assiduous application of fomentations and poultices, will expedite the suppurative process, and afford great relief to the animal. When the inflammation, or rather the swelling which it occasions, arrives at this state, it is termed an *Abscess*; in which, when the suppuration is complete, and it contains *matter*, a fluctuation may be felt upon its being pressed by two fingers alternately. This point being ascertained, an opening is to be made with a lancet or knife, in such a way that the matter may be completely evacuated, and a future accumulation prevented; it is then to be dressed with digestive liniment or ointment. Should the wound appear indisposed to heal when this treatment has been pursued for a short time, discharging a thin offensive matter, and wanting that red appearance by which the healing process is indicated, the detergent lotion (see PHYSIC) will soon remove those unfavourable appearances; the *discharge* will become whiter and thicker, and red granulations of new flesh will sprout up; should these granulations however, become luxuriant, constituting what is commonly termed *proud flesh*, they are to be kept down by means of the caustic powder. It sometimes happens, that when a part is inflamed and swollen, instead of going on to suppuration, it degenerates into a hard and almost insensible tumour; this depends on the inflammation having terminated in *effusion* of coagulable lymph, and is to be removed by stimulating embrocations or blisters.

Inflammation of the Lungs.—This is a very dangerous disease, and one to which horses are extremely liable; the frequency of its occurrence is occasioned by improper management, and not by any natural defect in the constitution of the animal; it may therefore be prevented by proper attention in the groom. Medical writers make a distinction between inflammation of the lungs, and of the pleura, or the membrane which covers those organs, calling the former *Peripneumony*, and the latter *Pleurisy;* this distinction, however, is not necessary in veterinary nosology, since we never find those parts affected separately in the horse. The progress of this disease is often very rapid, and unless proper remedies are employed at an early period, it frequently terminates fatally.

Its approach is indicated by the following symptoms: loss of appetite, an appearance of dullness, and disinclination to motion, unusual quickness in the motion of the flanks, hot mouth, and sometimes a cough. If the disease, by adopting an inert, or improper mode of treatment, is suffered to proceed, all these symptoms will increase; respiration will become extremely quick and laborious, the pulse more frequent, and at the same time weak. A striking appearance of uneasiness and anxiety may be observed in the animal's countenance: the nostrils expanded, the eyes fixed, and the head inclining downward; the legs and ears become cold, and the debility is so considerable, that he is incapable of moving in the stall without great difficulty; he never lies down unless so much weakened as to be incapable of standing. The disease, however, is not always so rapid in its progress as we have here described it, and not unfrequently a considerable remission may be observed, which is occasioned probably by an effusion of serum or water having taken place in the chest, and this remission is sometimes so conspicuous, that we are led to give a favourable prognosis; the horse beginning to feed again, and the pulse becoming less frequent. But this flattering appearance often proves fallacious, the disease soon returns with accumulated force, and puts a period to the animal's life. I have seen cases, where bleeding has not been performed with sufficient freedom, in which the inflammation being checked in some degree, at length terminated in a plentiful effusion of water in the chest; when this happens, the horse returns to his food, looks more lively, and, in short, the symptoms of fever in a great measure disappear. There remains, notwithstanding, an unusual quickness in respiration, generally accompanied with a cough; the hind legs swell, and the horse very rarely lies down; a rough unhealthy appearance may also be observed in the coat, the skin feeling as if stuck to the ribs, and the animal continues in a state of weakness; after some time the inflammation generally returns, and then speedily ends in death. It sometimes happens that the inflammation terminates in suppuration, in this case also the fever is in some degree lessened, and the horse begins to feed a little; but he still remains in a very feeble state, has a weak cough, and discharges fetid matter from his nostrils; at length the disease again becomes violent, and soon puts a period to his sufferings.

The first thing to be done when this dangerous disease is observed, is *to bleed copiously*, even till the horse begins to

faint from loss of blood. I have seen six quarts drawn at one operation, and with the best effect; sometimes indeed the disease will be completely subdued by thus bleeding freely at its commencement. Should the horse be costive, or even if the bowels are in a natural state, it will be advisable to give a pint of castor oil, and inject a glyster of water gruel; it will then be necessary, in order to divert the inflammation from this important organ, to insert rowels about the chest and belly, and to blister the sides extensively. Let the legs be kept warm by almost constant hand-rubbing,—and warm cloathing must never be omitted. Nothing is more pernicious in this complaint than compelling the animal to breathe the impure air and stimulating vapours of a close stable; this is indeed so obvious a truth, that it would be unnecessary to mention it, were it not a constant practice with grooms on this occasion to stop every crevice they can find by which pure air might be admitted, and the noxious exhalations suffered to escape.

If the disease does not appear to abate in twelve hours after the bleeding, particularly if it has become more violent, let that operation be repeated, and with the same freedom as at first; we need not be apprehensive at this early period of the disease, of any dangerous debility ensuing from the loss of so much blood; on the contrary, it will tend to reestablish strength, by subduing the inflammation on which the fever depends. It has been found necessary to bleed several times, and that very plentifully; but it must be recollected, that when the fever has existed for some time, and has nearly exhausted the horse's strength, bleeding seldom does good, and in some instances, I believe, has been the means of hastening death. When suppuration takes place in the lungs, though there is little probability of saving the animal, his life may be prolonged by giving frequently good water gruel and infusion of malt:—Opium, salt of hartshorn, and other cordials, will also be of service. I have generally given the following ball on those occasions, and though I have never seen a horse recover after extensive suppuration had taken place in the lungs, yet these remedies have certainly afforded considerable relief.

Salt of hartshorn, 1½ dr. opium, 1 dr. powdered aniseeds, ½ oz. and syrup enough to form the ball for one dose.

When the mode of treatment here recommended is adopted before the disease has gained much ground, it will generally succeed completely; considerable weakness will of course remain after the fever has been removed, but that also will gradually go off, if proper attention be paid to the horse's diet and exercise. When the appetite begins to return, it will be adviseable to give small quantities of oats that have been steeped in boiling water; good water gruel will also be found serviceable in recruiting his strength; the sweetest parts should be selected from the hay, and given frequently in small quantities. Malt is an excellent restorative on these occasions, but must not be given too freely. When the weather is favourable, let the horse be led out for a short time every day; or if a small paddock can be procured, and the season of the year will admit of it, he may be turned out for a few hours every day, while the sun shines, taking care that he is well cloathed during that time; by these means he will gradually recover his original strength.

Inflammation of the Bowels.—This disease is not so frequent as the preceding, though equally dangerous and generally more rapid in its progress. Inflammation may attack either the peritoneal coat of the intestine, or that delicate membrane which forms the internal or villous coat: in the former case the disease will be attended with costiveness, but in the latter a violent purging is the most conspicuous symptom; but which ever of these coats is first attacked, the inflammation, in a short time, generally spreads to the other.

The peritoneal inflammation begins with an appearance of dullness and uneasiness in the horse; the appetite is considerably diminished, or is entirely lost, and the pulse becomes more frequent; the pain and febrile symptoms gradually increase; he is continually pawing with his fore feet, and frequently endeavours to kick his belly; he lies down and suddenly rises again, and looks round to his flanks, strongly expressing by his countenance the violence of the pain he suffers; his urine is commonly high coloured, and in small quantity, and sometimes voided with considerable pain; he is generally costive, and the pulse remarkably small and quick; the legs and ears become cold, respiration is very much disturbed, and sometimes, from the violence of the pain and the animal's struggling, profuse perspiration breaks out; at length mortification takes place, and is quickly succeeded by death. Sometimes the progress of this disease is remarkably rapid; in one instance I have seen a complete mortification take place in the course of twelve hours, and that very extensively.

When only the *internal* coat of the intestines is inflamed, there is generally a violent purging, accompanied with febrile symptoms; these, however, are seldom so considerable as in peritoneal inflammation, nor does the animal appear to be in so much pain. This disease is commonly produced by the improper use of physic, or by neglecting a horse during the operation of a purgative.

In the treatment of peritoneal inflammation, *early and copious bleeding is the most important remedy.* The efficacy of artificial inflammation on the surface of the body is remarkably conspicuous in this disease; and I have seen even the actual cautery applied to the skin of the abdomen with manifest advantage. As a substitute for this severe remedy, I would recommend covering the back with fresh sheep skins, which will soon excite, and keep up for a considerable time, a copious perspiration on the part; the whole of the abdomen or belly should have the mustard embrocation assiduously rubbed upon it, the stimulating effects of which may be promoted by covering the part afterwards with sheep skins or warm cloathing. Rowels also may be inserted about the chest and belly, putting into them blistering ointment instead of turpentine, or the common digestive, which is usually employed for the purpose. Should the horse be costive, which, as we have before observed, is almost always the case, give a pint or twenty ounces of castor oil, and let glysters of fine water gruel be injected. He should be allowed to drink plentifully of warm infusion of linseed, or warm water alone; while hand rubbing to the legs, with a liberal allowance of litter, should not be forgotten. If the disease does not abate in six hours after the bleeding, the operation must be repeated, and if the costiveness continues ten or twelve hours after the oil has been taken, give another dose, and repeat the glyster. If the disease continues, and increases in violence, after all these remedies have been properly applied, there will be but little probability of recovery; particularly if the pulse has become so quick, weak, and fluttering, as to be scarcely felt; or if there appears to be a remission or cessation of pain, or the horse becomes delirious. These are always fatal symptoms, denoting that mortification is taking place, which is the certain harbinger of death; but should the pain continue after the above remedies have been fairly tried, the anodyne glyster may be injected.

With respect to the causes of peritoneal inflammation, the most usual appears to be high feeding and want of exercise; it is not unfrequently occasioned, however, by putting a horse suddenly into warm stables when taken from camp or grass. The fatal consequences of this management was often experienced in the army, I believe, (though a different cause was assigned,) before the veterinary art had made sufficient progress to point out its impropriety and danger.

In some instances the disease appears to have been produced by the distension which the intestines have suffered in flatulent cholic or gripes. where that complaint has been neglected or improperly treated, or where the *spasm* has been so violent as to resist the operation of every remedy.

An inflammation of the villous or internal coat of the intestine, we have before observed, is commonly occasioned by giving too strong physic, or by inattention during its operation, and is generally accompanied with profuse purging; in this case a different treatment is required from what we have recommended for peritoneal inflammation, and bleeding must not be employed, unless the pulse is much accelerated and the febrile symptoms considerable; the oil also must be omitted. Here the mustard embrocation, and sheep skins to the back and belly, are eminently useful.

It is of consequence to make the horse drink freely of fine water gruel, or linseed tea, which, if he refuses to drink must be given with a horn. If the disease continues, notwithstanding these remedies have been carefully employed, let the anodyne glyster be injected, and if that fails, give the anodyne or the restringent draught. It sometimes happens when a horse has taken physic, that gripes and violent sickness occur before the purging takes place; in this case, by means of a glyster, a plentiful exhibition of thin water gruel, and exercise, we shall produce an evacuation and relieve the animal. Peritoneal inflammation has sometimes been mistaken for flatulent cholic or gripes, but their appearances are very different, and they may easily be distinguished by referring to the annexed table, in which their symptoms are contrasted.

Restringent draught.—Opium, 1 dr. Prepared chalk, ½ oz. Compound powder of tragacanth, 1 oz. Mint water 1 pint.

Anodyne draught.—Opium 1½ dr. Water gruel, 1 quart. Mix for one dose.

Mustard Embrocation. Camphor, 1 oz. Oil of turpentine and water of pure

ammonia, each, 2 oz. Flour of mustard, 8 oz. To be made into a thin paste, and rubbed for a considerable time on the part.

Anodyne Glyster.—Opium, ½ oz. Water Gruel, 3 pints. Mix for one injection.

A table, shewing the difference between Flatulent Cholic or Gripes, and Inflammation of the Bowels.

Symptoms of inflammation of the bowels.

1 Pulse very quick and small.

2 Lies down and suddenly rises again, *seldom* rolling upon his back.

3. Legs and ears generally cold.

4. In general attacks gradually, is commonly preceded, and always accompanied by symptoms of fever.

5. No intermissions can be observed.

Symptoms of flatulent cholic.

1. Pulse natural though sometimes a little quickened.

2. Lies down and rolls upon his back.

3. Legs and ears generally warm.

4. Attacks suddenly, is never preceded and seldom accompanied by any symptoms of fever.

5. There are frequently short intermissions.

Inflammation of the Stomach.—The stomach, like the intestines, may be inflamed either on its *external* or *internal* surface. When the external coat is the seat of disease, the symptoms are nearly the same as those by which Peritonæal inflammation of the intestines is indicated, and the same treatment is required; the only difference observable in the symptoms is, that in this case the pain seems to be more acute and distressing than in the other: the same difference may be observed between the large and small intestines, the latter being possessed of more sensibility than the former

When inflammation attacks the peritoneal coat of the stomach, it very soon diffuses itself to the small intestines and neighbouring viscera; or if the small intestines be its original seat, it frequently spreads to the stomach, and sometimes to the large intestines also. In examining horses, therefore, that have died, of these diseases, we seldom find the inflammation confined to one partitular organ; it more commonly happens, indeed, that the whole of the abdominal viscera will exhibit morbid appearances, but in different degrees; those most contiguous to the part first diseased having suffered considerably, while such as are more remote from it are perhaps scarcely altered; for we can generally distinguish the original seat of the inflammation.

An inflammation of the *Internal* or *Villous* coat of the stomach is not a very common disease, and is generally occasioned either by poisons or strong medicines that have been swallowed, or by that species of worms termed Botts. When poisons, or strong medicines incautiously given, are the cause, it will of course come on suddenly; the pulse will be extremely quick, and so weak that it can scarcely be felt; the extremities will become cold, and there will be a peculiar dejected appearance in the animal's countenance,—respiration will be disturbed: sometimes there will be a cough, and always a high degree of debility. The treatment of this disease consists in giving oily or mucilaginous liquids freely, such as decoction of linseed, gum arabic dissolved in water, &c and at the same time medicines that are capable of decomposing or destroying the poison: for this purpose I believe the sulphurated potash is useful in doses of half an ounce, provided the poison be either mercurial or arsenical. Glysters are to be injected, and if the disease is accompanied with purging, they should be composed of strong linseed decoction or water gruel I saw five cases of inflamed stomach at one time, (all occasioned by poison)—the above treatment was pursued, and four out of the five perfectly recovered.

That inflammation which botts produce in the stomach, is indicated by symptoms sometimes different from those just described: indeed it may more properly be considered as ulceration of the stomach than inflammation, since, upon examining horses that have died of this complaint, I have always found ulcers of considerable size. This disease generally comes on gradually: the horse becomes hide-bound, has a rough unhealthy coat, gradually loses flesh and strength, though he continues to feed well, and has a frequent and troublesome cough. The disease perhaps will continue in this state for some time, and no serious consequences are apprehended; its cause and seat are seldom suspected, medicines are given to remove the cough, with common alteratives for the purpose of improving his condition.

In some instances these insects are spontaneously detached, and expelled through the intestines: in such cases, if the stomach has not been much hurt by them, it will gradually recover, and the horse be restored to his original strength and condition. When this does not occur, these worms produce so much mischief in the stomach, as to throw the whole system into disorder. The lungs are particularly liable to sympathise with the stomach in this case, and frequently

become inflamed in consequence. The inflammation thus produced in the lungs is extremely obstinate, and though it may be checked in some degree by bleeding, and the other remedies we have recommended for that disease, yet as the cause cannot often be removed, it generally, I believe, terminates fatally. This symptomatic inflammation of the lungs may be distinguished from the idiopathic or original, by the following criterion:—It is generally preceded by an unhealthy appearance in the coat, and a troublesome cough; the animal seldom bears bleeding well, the loss of any considerable quantity of blood causing a rapid diminution of strength; whereas, in the idiopathic inflammation of the lungs, the strength of the pulse, as well as the whole system, is often increased by bleeding.

With respect to the remedies for this disease, those recommended for inflammation of the lungs are the best; but when the stomach has been considerably injured, there is little prospect of success. Infusion of malt has been recommended for the purpose of inducing bots to disengage themselves; (See Index, *Bots.*) I must confess, however, that I have never seen any thing effectually remove them, though they frequently come off spontaneously, particularly in Spring. I have taken occasion to examine the bodies of several horses which had been destroyed in this way: in all of them there was mortification and suppuration of the lungs, which appeared to have been the *proximate* cause of death, but on opening the stomach an immense number of bots was found, many of them attached to the *sensible* part, and to the pylorus or beginning of the intestine; in every instance there were ulcers of considerable size found; in some the coats of the stomach had been nearly destroyed. It appeared very clearly, I think, in all these cases, that the disease of the stomach was antecedent to that of the lungs.

It must not be supposed, from what has been said on this subject, that bots cannot exist in the stomach without producing all this mischief; on the contrary, they are often found in healthy horses that have been shot or otherwise destroyed, and it has been known that such horses have suffered no apparent inconvenience from them during life. In all these instances, however, they have been attached to the upper or *insensible* coat of the stomach.

Inflammation of the Kidneys.—This disease does not occur very frequently, and is often occasioned, I believe by an immoderate use of strong diuretic medicines. At the first attack of this complaint the horse constantly stands as if he wanted to stale, sometimes voiding a small quantity of high coloured or bloody urine; when the inflammation becomes more considerable, a suppression of urine and fever generally take place; if the loins are pressed upon, the animal shrinks from it, and appears to feel great pain. In the first place, bleed freely, then give a pint or twenty ounces of castor oil, throw up glysters of warm water, and cover the loins with sheep skins, having previously rubbed upon them the mustard embrocation; should these remedies fail of procuring relief, repeat the bleeding, and should the oil not have operated sufficiently, let another dose be given. All diuretic medicines are to be carefully avoided.

Inflammation of the Liver—This disease is indicated by a yellowness of the eyes and mouth, red or dark coloured urine, great weakness, and fever, generally accompanied with diarrhœa or purging, and sometimes with costiveness; the horse has a very languid appearance, and is almost constantly laying down. Sometimes the progress of this complaint is very rapid, speedily terminating in death; at others it proceeds more slowly, the animal lingering for a considerable time; in this case it not unfrequently terminates in dropsy, or inflammation of the bowels. A case we recently met with, terminated in this way. It is often complicated with other internal diseases, causing some variety in the symptoms.

Bleeding can only be employed with safety at the commencement of this disease; afterwards it generally does harm, by inducing a dangerous degree of debility. The sides should be blistered, and if there be no purging, the Ball No. 1, given, once in twelve hours, until it occasions moderate purging; but if the bowels are already in a lax state, the Ball, No. 2 or 3, will be better adapted to the complaint, and is to be given in the same way.

The Ball—No. 1. Calomel, ½ dr. Barbadoes aloes, 1 dr. Castile soap, 2 dr. rhubarb, ½ oz. Syrup enough to form the Ball for one dose.

No. 2.—Opium, ½ dr. to 1 dr. calomel, 1 dr. Castile soap, 2 dr. Syrup enough to form the Ball for one dose.

No. 3—Opium and calomel, of each, 1 dr. emetic tartar, 2 dr. liquorice powder, 3 dr. Syrup enough to form the Ball for one dose.

Of Jaundice—This disease sometimes exists independent of inflammation of the liver, and may be distinguished from it by the absence of fever and debility, which always attend the former disorder.

Its principal symptom is yellowness of the mouth and eyes, with purging. The cure consists in giving once a day to the horse, till he begins to recover, the following ball.

Ball—Opium 1 dr. calomel, 1 dr. Syrup to form one ball.

Fistula in the withers.—This disease generally originates in a bruise from the saddle, and is at first simply an abscess, which by early attention and proper treatment may be easily cured; but when neglected it degenerates into a fistulous sore, proves extremely difficult of cure, and cannot be removed without very severe treatment.

As soon as the injury is discovered, fomentations should be applied in order to promote suppuration, and when matter is formed let the tumour be opened, so that its contents may be completely evacuated, and a future accumulation prevented; the sore may then be healed by dressing it daily with digestive liniment or ointment; but should these prove ineffectual, apply the detergent lotion until the sore assumes a red healthy appearance, and the matter becomes whiter and of a thicker consistence. When the disease has been neglected in its first stage, and the matter suffered to penetrate among the muscles, affecting the ligaments or bones of the withers, it becomes *necessary* to adopt a more severe treatment. The sinusses or pipes are to be laid open with a knife, and if it is practicable, a depending opening is to be made, that the matter may run off freely; the sore is then to be dressed with the following ointment, which is to be melted and poured into the cavity while very hot.

The sore is not to be dressed, until the sloughs which this ointment occasions have separated from the living parts; which generally happens two or three days after the operation. If the surface of the sore looks red and healthy, and the matter appears to be whiter and of a better consistence, a repetition of this painful operation will not be required, the digestive liniment or ointment being sufficient to complete the cure; but should the sore still retain an unhealthy appearance, and the matter continue thin and of a bad colour, the hot dressing must again be applied.

The ointment.—No. 1. Ointment of nitrated quicksilver, 4 oz. Oil of turpentine, 1 oz. Mix.

No. 2. Verdigris, ½ oz. Oil of turpentine, 1 oz. Ointment of yellow resin, 4 oz. Mix.

Flatulent Cholic, Gripes, or Fret.—This disease generally attacks rather suddenly, and is brought on by various causes; sometimes it is occasioned by drinking a large quantity of cold water when the body has been heated, and the motion of the blood accelerated by violent exercise. In horses of delicate constitutions, that have been accustomed to hot stables and warm clothing, it may be brought on merely by drinking water that is very cold, though they have not been previously exercised. Bad hay appears to be another cause of the complaint; but it frequently occurs without any apparent cause, and then probably *depends* upon a spasmodic action of the stomach or bowels, occasioning a constriction of the intestine, and a confinement of air. The air which is thus confined, does not appear to be produced by fermentation of the contents of the intestine; but I have been informed, that the air which is confined in the intestines of persons who have died of the disease termed Tympany, consists, in great measure, of azotic or nitrogene gas, which could not have been the product of fermentation. This opinion will appear still more probable, when we consider the immense quantity of air that is sometimes discharged from the human stomach, even after its contents have been expelled by vomiting.

The pain and uneasiness which this complaint occasions are so considerable as to alarm those who are not accustomed to see it, and lead them to be apprehensive of dangerous consequences; but if properly treated, it may be easily and expeditiously removed. It begins with an appearance of uneasiness in the horse, frequently pawing the litter, he voids a small quantity of excrement, and makes fruitless attempts to stale; the pain soon becomes more violent, he endeavours to kick his belly, and looks round to his flanks, expressing by groans the pain he labours under; at length he lies down, rolls about the stall, and falls into a profuse perspiration. After a short time he generally gets up, and appears for a minute or two to be getting better, but the pain soon returns and the succeeding paroxysm is generally more violent than the former—the pulse is seldom much accelerated, nor are there any symptoms of fever. The disease will sometimes go off spontaneously; it more commonly happens, however, when proper remedies are not employed, that the air continues to accumulate, and so distends the intestine, as to produce inflammation of its coats; the distension has sometimes been so considerable as to rupture the intestine, whereby the horse is speedily destroyed.

As soon as this disease is observed, let one of the following draughts be given, and a glyster injected, composed of six quarts of water gruel or warm water, and 8 oz. common salt. If the disease has existed for several hours, and the pain appears to be very considerable, particularly if the pulse has become quick, it will be adviseable to bleed to three quarts, with a view to prevent inflammation and remove the spasmodic contraction of the intestine. If the disease, however, is perceived on its first attack, the draught and glyster will generally be sufficient to cure it; but should no relief be obtained by these means in an hour or two, let the draught be repeated, and let the belly be rubbed for a considerable time with the mustard embrocation. Should the disease be so obstinate as to resist even these remedies, which will scarcely ever happen, give a pint of castor oil, with 1½ oz. tincture of opium: as soon as the horse gets up, let him be rubbed perfectly dry by two persons, one on each side, and afterwards let him be well clothed. It is necessary in this complaint to provide a large quantity of litter, for the purpose of preventing the horse from injuring himself during the violence of the paroxysm.

The Draught. No. 1. Balsam of capivi, 1 oz. Oil of juniper, 2 dr. Spirit of nitrous ether, 1 oz. Simple mint water, 1 pint. Mix for one dose.

No. 2. Venice turpentine, 1 oz. Mix with the yolk of an egg, and add gradually—peppermint water, 1 pint. Spirit of nitrous ether, ½ oz. Mix for one dose.

No. 3. Camphor, 2 dr. Oil of turpentine, ½ oz. Mint water, 1 pint. Mix for one dose.

As this complaint is liable to occur during a journey, in situations where the above remedies cannot be readily procured, I have annexed a formula for a ball, for the convenience of those who are in the habits of travelling. If this ball is wrapped up closely in bladder, it may be kept a considerable time without losing its virtues.

The Ball—Castile soap, 3 dr. Camphor, 2 dr. Ginger, 1½ dr. Venice turpentine, 6 dr. To be made into a ball for a dose.

Diseases of the Foot.—The most frequent cause of lameness in the foot is, a contraction of the horny matter that composes the hoof, generally accompanied with an increased concavity and thickness of the sole. The cavity of the hoof being thus diminished, the sensible foot suffers a greater or less degree of compression, which occasions in it inflammation and lameness. When we examine the bottom of a contracted foot, instead of being circular, it will be found of an oblong form, the heels and frog will appear as if they had been squeezed together. Sometimes the frog has become rotten, and discharges an offensive matter.

The sensible foot may also be compressed and inflamed by an increased thickness, and a consequent loss of elasticity in the hoof and sole, and in this case there is seldom any considerable alteration observed in the external form of the foot.

We sometimes meet with horses that go perfectly sound, though their hoofs are much contracted; on the other hand we often see severe lameness produced by a slight degree of contraction. In attempting to cure this disease, the first step to be taken is to remove carefully with a knife all the rotten parts of the frog, and apply tar to those which are sound: a small quantity should also be poured into the cleft of the frog; this will promote the secretion of horny matter, and if assisted by pressure, will increase the solidity of that which is already formed. The quarters and heels are then to be rasped, particularly at the coronet, and the superfluous parts of the sole removed with a butteris and drawing knife. The toe is to be shortened as much as can be conveniently done, and if the heels are too high, that is, if the crust at the heels is too deep, it will be necessary to reduce it with the butteris and rasp. It frequently happens, however, in feet of this description, that the heels are too low, in such cases they must be carefully preserved, and when a shoe is applied, it should be made thicker at the heel than at the toe, and somewhat longer than that recommended for a sound foot.

When a contracted hoof has been thus treated, the next thing to be done is to keep the foot as moist as possible, and expose the frog constantly to pressure, either by means of the artificial frog, or by reducing the crust at the heels. When these remedies have been persevered in for a short time, the frog will have acquired a certain degree of hardness and solidity; it will then be proper to turn the horse out into some soft meadow ground, without shoes, taking care that the bottom of the foot is occasionally reduced, so that the frog may constantly receive pressure. If the foot is examined after a short time, it will be found that all the new formed hoof at the quarters

and heels, that is all the horn that has been produced at those parts since the remedies were first employed, instead of growing down nearly in a perpendicular direction, or obliquely inward, is forced outward in its descent, so that the cavity of the hoof will be considerably enlarged, and the compression of the internal parts removed. When the horse has been at grass a sufficient time for the new hoof to grow completely down, the shape of the foot will be found much altered; the heels, instead of being narrow, will be open and expanded, the Frog will be considerably widened, and not squeezed together as before, and the oblong form will be changed to one that is more circular; in short, when the frog during this time has been properly exposed to pressure, and the quarters so rasped as to be rendered sufficiently flexible, the hoof will be found very similar in its form to that of a Colt.

In cases where a contraction of the hoof has already produced inflammation and lameness, particularly if the lameness is not recent, it will be adviseable to blister the pasterns previous to turning the horse out, and when the inflammation is very considerable, a laxative ball, with a cooling diet, will be serviceable. The cruel operation of drawing or tearing off the sole has been recommended as a remedy for contracted feet, but very little reflection will convince any one of its inefficacy; whenever it has been supposed to do good, the benefit has probably arisen from the long run at grass that becomes necessary after it, and then the advantage might have been equal, perhaps greater, had the operation been omitted. It has been observed before, that in contracted hoofs there is generally an increased concavity in the sole, whence we may reasonably conclude that it opposes the contracting causes, though in the end it is not capable of preventing the contraction from taking place. Upon a horse that has been lame from this disease a considerable time, it is difficult, if not impossible, to perform a radical cure; in such cases I have several times succeeded in removing the lameness, but the internal parts had become so irritable, or their organization had been so altered, that very moderate work would cause the lameness to return. When the lameness is not so considerable as to render the horse totally unfit for work, it will be adviseable to apply a shoe that is thicker, wider, and longer at the heels than that recommended for a sound foot, and if the frog is tender and rotten, the bar-shoe will be found serviceable (Plate 3, Fig. 7.) It will be useful also to keep the hoof as moist as possible, by making the horse stand in wet clay four or five hours during the day.

In examining the feet of Horses after death, that have been thus treated, we find generally that the laminæ have been destroyed, the form of the coffin bone altered and its size diminished, or the lateral cartilages ossified: in some cases however, no appearance of disease can be perceived on the internal parts of the foot. When the disease has gone so far as to injure the laminæ, cartilages, or coffin bone, there is not a possibility of removing it, which shews how necessary it is to attend to the feet of horses more than is commonly done; and that whenever any alteration is perceived to be going on in the shape of the foot, when the heels appear to be getting narrower, the frog squeezed together and discharging matter, in consequence of the compression which the sensible frog suffers, it surely must be of importance to adopt such measures as will not only prevent the disease from going any farther, but will also restore the foot to its natural healthy state, for when it has gone so far as to produce absolute lameness, the cure is by no means certain. How frequently do we meet with horses that are said to be tender in the feet! and how subject are they to fall in consequence of this tenderness, which generally arises from contraction of the crust! In this case the sensible frog is extremely irritable and inflamed, and the horny frog which nature designed for its protection being soft or rotten, and inadequate to its function, every blow that it receives must of course give the animal very considerable pain, and I have known many valuable horses thrown down in this way; since however high and wide the heel of the shoe may be, the frog will be subject to occasional blows from sharp projecting stones. Whenever therefore any of those symptoms make their appearance, and whenever the foot seems to be undergoing an alteration in form, immediate recourse should be had to the mode of prevention we have pointed out.

The next disease to be noticed is the flat and convex sole, or, as it is more commonly termed, the pumice foot. This disease most commonly occurs in heavy draft horses, and seems to arise from a weakness of the crust; for when the sole becomes flat or convex, the crust also loses its proper form and becomes flatter, appearing as if it had been incapable of

supporting the animal's weight, and had therefore given way, allowing the internal foot to press so upon the sole as to give it the appearance we observe. This explanation of the disease will perhaps appear better founded, if we consider that, when a horse is drawing a heavy load, not only his own weight, but great part of that which he is drawing also, is thrown ultimately upon his feet, and as the fore feet support by far the greatest share, it is not at all astonishing that the crust should sometimes give way; for though it possesses sufficient strength for the purposes of the animal in a state of nature, yet that strength is limited, and not always adequate to the heavy burthens which the crust has to sustain. When the sole becomes flat or convex, it is rendered also thinner than it is naturally, and sometimes so much so as to yield easily to the pressure of the finger; the sole in this state is of course incapable of affording sufficient protection to the sensible sole, which is then closely in contact with it; and if it be exposed to pressure, lameness must be the consequence. It is almost superfluous to observe that the flat shoe would be ill adapted to a foot of this description; it becomes necessary in this case to apply one that is concave on its internal surface, that the sole may not receive any pressure from it, and of sufficient width to protect the sole as much as can be done from the pressure of the ground. In Plate 3, Fig. 6, this shoe is represented in which it may be observed, that although the internal surface is concave, still there is a flat surface for the crust to bear upon. In attempting to cure this disease, it is first necessary to take off the horse's shoes, and to make him stand on a flat hard surface; this kind of pressure will harden the soles, and in the end render them thicker, particularly if tar be frequently applied to them. I cannot say that I have ever seen the disease radically cured by this treatment, but I have known considerable advantage derived from it, especially in one case, where the soles, from being convex and very thin, became flat and sufficiently firm to bear moderate pressure without inconvenience to the horse.

We sometimes meet with horses, particularly among those that are well bred for the turf, whose pasterns are remarkably long and oblique in their position, while the heels are very low, and the toe of considerable length; if thin heeled shoes were applied to feet of this description, or if the toes were not kept short, the horse would be very liable to lameness, from the extraordinary pressure to which the ligaments and back sinews would be exposed; the heels therefore of such horses are to be carefully preserved, and the toes kept as short as possible. The shoes which are applied should be made sufficiently thick and long at the heel to make up for the deficiency of horn in that part, in order to relieve the ligaments and back sinews, and with the same view the toe should be made rather thin, and of the best steel.

There is another kind of deformity sometimes observable in the foot, that is, the hoof loses that oblique form represented in Plate 3, Fig. 9. and approaches towards the perpendicular, (Fig, 3,) at the same time the heels become very high; in this case it is necessary to reduce the crust at the heels, and apply the thin heeled shoe.

Gangrene.— When inflammation runs very high, as is sometimes the case in violent bruises, or deep and extensive wounds of the lacerated kind, it may terminate in *gangrene* or mortification, which is generally attended with danger; in this case the matter discharged, instead of being white and thick, consists of a dark coloured fluid, of a peculiar offensive smell; the constitution is generally affected, the pulse becoming quick, weak, and sometimes irregular, the appetite goes off, and there is a great degree of debility. Should the inflammation terminate in this way, if it arises from a wound, let it be dressed with digestive liniment, oil of turpentine, or camphorated spirit of wine; the diseased parts should be scarified, and fomentations applied almost incessantly, until the mortified parts appear to separate, and the matter loses in great measure its offensive smell, appearing whiter and more thick. When the horse is weakened by the disease, and loses his appetite, particularly if there is a copious discharge from the wound, one or two of the following cordial balls are to be given daily:

No. 1. Yellow Peruvian bark, 1 oz. Ginger, powdered, 2 dr. Opium, 1 dr. Oil of carraways, 20 drops. Syrup enough to make the ball for one dose.

No. 2. Yellow Peruvian bark, ½ oz. Powdered snake root, 2 dr. Powdered cassia, 1½ dr. Oil of cloves, 20 drops. Syrup enough to form the ball for one dose.

Remark.—The opium in the ball, No. 1, is to be omitted when the horse is costive, or if it appears to take off his appetite; but when the disease is accompanied with a purging, it is extremely useful.

When any of the *internal parts* are inflamed, a *fever* is generally produced, the violence of which will depend upon the importance of the inflamed organ, as well as upon the extent of the inflammation; some of the internal parts being more essential to life than others, and when inflamed occasioning of course greater derangement in the system. The only *favourable* terminations to which internal inflammation can be brought, are resolution and effusion; and as the first is by far the most desirable, the most vigorous measures should be adopted in order to effect it; the most important remedy in those cases is *copious bleeding*, and the earlier it is employed the more effectual will it prove: the next remedy is *external inflammation*, artificially excited by means of rowels and blisters. The fever powder, and occasional glysters, are of considerable service.

Of Glanders.—This is the most destructive disease afflicting the horse, being highly contagious, and almost universally fatal. The symptoms are a swelling of the glands under the throat, and a discharge of purulent matter from the nostrils: most commonly the discharge is confined to one nostril, and the inflammation is also limited to the gland on that side. Soon after this, the membrane lining the inside of the nose ulcerates, as may be seen by looking into the nostril, and the discharge becomes of a worse colour, and fetid; the ulceration now spreads: the thin, delicate, bony parts of the nose are destroyed by the virus, which is increased in quantity and virulence, and the whole system of the animal being at length affected, the vital functions gradually fail, and death closes the progress of this cruel disease: but its progress to destruction is more or less rapid in different horses: some it kills in a comparatively short time, while other horses not only sustain their condition, but are also able to endure work long after they have been undoubtedly glandered. This practice, however, of preserving glandered horses while they are capable of affording service, and which but a mistaken interestedness of the owner can approve, is highly injurious to the nation at large, and therefore ought not to be permitted.—A horse labouring under glanders may be considered a machine which is constantly generating and scattering around him the glanderous poison; every thing to which he applies his nostrils has this poison deposited on it; the manger and rack from which he eats, the pail in which he drinks, the collar, bridle, and clothes he may have on, all are infected; even the parts of the stable that are contiguous, but with which he may not have had absolute contact, are not exempt from the infection of this dreadful disease: the glanderous matter on the membrane of his nose, carried forth by the air which he expires in breathing, vitiates the atmosphere around him, and spreads the seeds of further infection to a distance from the animal.

At present there is no effectual remedy known for preventing or curing this disease: from a corresponding appearance between some of its symptoms with those of the venereal disease, and seeing the effects of mercury in curing the latter, various preparations of quicksilver, in different doses, have also been given to the horse, with the view of curing the glanders, but not with the same happy effect. This failure, however, should not preclude the hope that a specific remedy for at least suppressing the mortality of the distemper, may not, ere long, be discovered. The cow-pock was not thought of as being an infallible preventive against the mortality of the small-pox, and a successful remedy against this virulent and frequently fatal disorder was beginning to be despaired of, until the sagacious *Jenner* made the immortal discovery; a discovery which, in some measure, atones to humanity for the unparalleled destruction of the species, committed by the then existing ruinous and barbarous war. It is probable that a certain preventive against the mortality of the glanders also exists in some milder and more original disease, and only waits a few lucky circumstances to be discovered by some sagacious observer. It was thought the cow-pock would have had the desired effect, and accordingly the horse was inoculated with it, but wihout success.

It is admitted that glanders is generally spread by contagion; but it is also supposed, cases occur where this disease arises spontaneously. The latter supposition, however, rests merely in suggestion, where the disease cannot be traced to a contagious source; but considering the subtlety and virulence of the poisonous matter generated and constantly deposited by a horse infected with the glanders, it is not unreasonable to believe that this disease, in all cases, is produced by contagion, A neglected cold, ill cured strangles, and the breathing impure air, have been thought to be productive of glanders; but is it not possible that incipient glanders might have been mistaken for the two first diseases; and that in the case of breathing foul air, the ani-

mal might have received the infection into his system prior to being placed in so noxious a situation. These however, are suggestions also, unproved by facts, which can alone enable us to draw certain conclusions with regard to diseases; and they are offered here, principally, with the view of inducing practitioners of talent and observation to direct their views to the discovery of a preventive against the mortality of this dreadful disease.

Until, however, a remedy be discovered for preventing or curing the glanders, every horse certainly known to be infected with this disease, excepting such as may be left with skilful practitioners for experiment, ought to be immediately kept separate, with the view of preventing the extension of the contagion to other horses; but care should be had, that a cold or strangles be not mistaken for glanders, and the horse be improperly doomed to seclusion. To prevent such error, it will be necessary to discriminate between the symptoms of the different diseases: in a cold, there is mostly some fever with a cough, and the discharge at the nose is generally from both nostrils, which are never ulcerated. In the glanders, particularly in its early stages, there are neither cough nor fever; the discharge is mostly confined to one nostril, and there is always ulceration after a certain time. Again, strangles differ from glanders in this; that the inflamed glands under the throat soon run to suppuration in the former disease; and, discharging their matter, the animal gets well; whilst, in glanders, these glands are scarcely ever known to inflame actively and suppurate.

When then a horse is observed to have a discharge at the nose, he should be instantly separated from all other horses, until the nature of the discharge be known; when, if it proceed from glanders, the animal should be kept separate, and destroy the things he was most likely to have infected, as the collar, nose-bag, &c. and it will be requisite afterwards to wash clean the rack, manger, and other places on which he may have deposited glanderous matter; and to ensure safety against further contagion, a coat or two of lime should be given to the stable inside.

Lampas.—When the bars or roof of the horse's mouth, near the front teeth, become level with, or higher than the teeth, he is said to have the *Lampas*, and this is supposed to prevent his feeding. Farriers burn down this swoln part with a red hot iron made for the purpose. I believe this operation is performed much more frequently than is necessary, but I have never seen any bad consequences arise from it.

Locked Jaw.—This disease, fortunately does not occur very often, and generally terminates fatally. It begins with a difficulty in mastication; at length the jaws become so completely and immoveably closed, that neither medicines nor food can be got into the stomach: the muscles of the neck are generally in a state of rigid contraction, and the animal appears to suffer great pain; it is often brought on by trifling causes, such as wounds of the foot, inflammation of the tail, from docking or nicking, &c. and sometimes it attacks without any apparent cause. Various remedies have been tried in this complaint, but I do not think any effectual mode of treatment has yet been discovesed; immersion in cold water, or even snow, is said to produce a temporary relaxation of those muscles by which the jaws are closed. Opium and camphor have been strongly recommended. I have lately been informed of a case in which a combination of these medicines completely succeeded. In America and the West India Islands, where the disease is much more frequent than it is in this climate, strong stimulants have been found effectual; it would be adviseable therefore to try the same plan on horses should opium and camphor fail. The best stimulants for this purpose are spirits of hartshorn, ether, opium, and brandy.

In every case of locked jaw, the injured part should be burnt with a red hot iron, and if no particular part is injured, the same application should be freely made in the neck.

Lymph, Coagulable Effusions of. See INFLAMMATION.

Mallenders and Sallenders.—When a scurfy eruption appears on the posterior part of the knee joint, it is termed *Mallenders*, and when the same kind of disease happens on the anterior of the hock joint, it is named *Sallenders.* Should these complaints occasion lameness, it will be proper to give in the first place a dose of physic; let the hair be carefully clipped off from the diseased part, and let all the scurf be washed off with soap and warm water; a cure may then be soon effected by applying the following ointment twice a-day:

The Ointment.—No. 1. Ointment of wax or spermaceti, 2 oz. Olive oil, 1 oz. Camphor and oil of rosemary, of each, 1 dr. Acetated water of litharge, 2 dr. Mix.

No. 2. Ointment of nitrated quick-silver, olive oil, of each, 1 oz. Mix.

No. 3. Oil of turpentine, ½ oz. Vitri-

olic acid, 1 dr. Mix cautiously, and add of oil of bay, 3 oz. Mix.

Mange.—This disease is seldom met with, except in stables where scarcely any attention is paid to the horses, and where their food is of the worst quality: it is certainly very contagious, and may in that way attack horses that are in good condition. It is known to exist by the horse constantly rubbing or biting himself, so as to remove the hair, and sometimes produce ulceration; the hair of the mane and tail frequently falls off, and small scabs are observable about the roots of that which remains. The mange is, I believe, a *local* disease, and requires only the following ointment or lotion for its removal: in obstinate cases, however, it may be adviseable to try the effect of the following alterative.

Mange Ointment.—No. 1. Sulphur, vivum, finely powdered, 4 oz. Oil of turpentine, 3 oz. Hog's lard, 6 oz. Mix.

No. 2. Oil of turpentine, 4 oz. Strong vitriolic acid, ½ oz. Mix cautiously, and add train oil, 6 oz. Sulphur vivum, 4 oz. Mix.

Mange Lotion.—White hellebore, powdered, 4 oz. Boil in 3 pints of water to 1 quart, then add muriate of quicksilver, 2 dr. that has been previously dissolved in 3 drams of Muriatic acid.

Alterative for Mange.—Muriate of quicksilver, ½ oz. Tartarized antimony, 3 oz. Powdered aniseeds, 6 oz. Powdered ginger, 2 oz. Syrup enough to form the mass, to be divided into sixteen balls, one of which is to be given every morning.

Should they appear to diminish or take off the appetite, or create a purging, they must be discontinued two or three days.

Mortification. See GANGRENE.

Of Ophthalmy.—This consists in an inflammation of the conjunctiva, or membrane lining the eye-lids, and reflected over the fore part of the eye; it first attacks the part lining the lids; then that on the white, or opake, coat of the eye; and, lastly, the portion spread over the transparent cornea. In the former parts it produces great redness and fullness of the blood-vessels, as may be seen by gently drawing either lid from the eye; while in the latter, or transparent part of the eye, a dullness, or film-like appearance, is the consequence. The tears are, at the same time, so much increased as to flow over the face; the lids are partly closed, to exclude some of the light, and which would now be painful and injurious to the eye, rendered irritable by the inflammation; and the more effectually to avoid irritation from abroad, the animal draws the diseased eye farther into the orbit, by means of the retractor muscle, which, at the same time that it effects this motion, forces the haw, as we before observed, outwards, to increase the protection of the eye. Some persons mistaking the haw for an excrescence produced by, or producing, the disease, used to cut it away, and, consequently, deprived the horse's eye of a material part of its defence; but now its use beginning to be understood, it is rarely removed, except by the most uninstructed practitioners.

When the above symptoms are caused by blows, or other accidents, a cure is soon effected by bleeding, and giving the following laxative balls twice or three times, after an interval of a few days between each, and keeping the animal at rest, and on a cooling diet: and should any speck, or appearance of opacity, remain on the transparent part of the eye, after the inflammation has subsided, a little finely powdered salt blown on the part through a quill, once or twice a day, will gently stimulate the absorbent vessels, and shortly remove the opacity.

Poll Evil.—The poll evil, so called from taking place in the poll, or upper part of the neck close to the head, arises from bruises, or blows on the part, and is, at first simply an abscess confined to the cellular membrane between the muscles of the part; and may, in this stage, be easily cured by early and proper treatment, like other abscesses: but, on the other hand, if the disease be neglected, as is more commonly the case, till the matter find its way to the ligaments and bones underneath, it then becomes much more difficult of cure, and requires a severer treatment.

In this case it will be necessary to lay open the different sinuses; and also, when there is opportunity, to make a depending opening for the matter to discharge itself by. The following corrosive and highly stimulating ointment should then be poured into the cavity, while hot, with the view of destroying the diseased surfaces of the sinuses, and also producing a healthy inflammation, and matter for filling up and healing the cavities. This mode of treatment, though severe, is yet the most likely, if judiciously proceeded in, to effect a cure of this very obstinate disease; and should it be found that applying it once has not been sufficient to destroy totally the diseased parts, it will be requisite to repeat it; after which the sore may be dressed, as a common abscess, with digestive ointment.

Ointment. Oil of turpentine 1 oz. Verdigris ½ oz. Ointment of yellow resin, 3 oz. Mix.

Quittor.—This disease generally arises from a wound or bruise in the coronet, and if neglected, penetrates under the hoof, forming sinuses in various directions. The most effectual method of treating those complaints is to ascertain, in the first place, the direction and extent of the sinuses, and then to force into them with a strong probe some crystallized verdigris, rolled up in thin blotting or silver paper. This, though apparently a severe remedy, will be found very effectual. Sublimate and arsenic have been strongly recommended as remedies for the quittor, indeed it is probable that any caustic application would effect a cure; but I have succeeded so well with the chrystallized verdigris, that I have not been induced to try those medicines. When a corn has been neglected and suffered to break out at the coronet, or when the foot has been wounded, or *pricked*, as it is termed, by the farrier in shoeing, and this is not discovered until matter appears at the coronet; though these may be considered as cases of quittor, a different treatment is required from that we have just described; in those cases the cure greatly depends on making an opening for the matter in the bottom of the foot, where the nail which inflicted the injury entered; or if produced by a corn, the opening must be made in the angle between the bar and crust, at *e*, fig. 1, plate 3. The best dressing on those occasions is the compound tincture of benzoin and digestive ointment; a poultice is sometimes required to soften the horny matter, and subdue any inflammation that may exist in the foot.

Ring-Bones. Are bony excrescences about the small pastern bone, near the coronet, or an ossification of the cartilages of the foot. If observed in its incipient state, a blister will probably be of service; but when of longer standing and large, the actual cautery will also be necessary: this remedy, however, is by no means uniformly successful, the complaint being frequently incurable, and if it has proceeded so far as to cause a stiff joint, there is no chance of recovery.

Roaring. This disease takes its name from a peculiar sound in respiration, particularly when the horse is put into a brisk trot or gallop. It seems to arise from lymph that has been effused in the windpipe or its branches, which becoming solid, obstructs, in a greater or less degree, the passage of air. As a remedy for this complaint, blistering the whole length of the windpipe has been recommended; I believe, however, that it is always incurable.

Saddle Galls.—The skin under the saddle is frequently liable to be so injured as to run into inflamed tumours called saddle galls or warbles.

These are sometimes troublesome, if not attended to in time; but by an early application of some repelling solution, as sugar of lead and water, or vinegar, the tumour may be soon discussed: if, however, matter has formed, it should be evacuated by the lancet, and the sore afterwards healed as on ordinary occasions.

Sand Cracks.—The crust of some horses is liable, in the dry season, to be affected with fissures, which generally run from the coronet downwards: they are to be found mostly at the sides of the crust approaching the heels. When they do not enter deep they produce scarcely any inconvenience to the animal; but on the contrary, if they descend to the sensible parts of the foot, they necessarily cause great pain and lameness, and require much attention to remove them.

As excessive dryness of the crust appears to be one of the causes producing sand-cracks, moisture is evidently necessary to prevent them, and also to assist the cure where they do exist; and with this view the crust so cracked should be kept constantly moist, either in the stable, or by turning the horse out into moist ground. But first it will be necessary to thin the quarter, and after opening the line of crack with a drawing-knife, to apply a hot iron with the view of exciting inflammation, by which a matter will be discharged, which will tend to fill up the crack, and defend the internal parts; gradually, as the hoof grows downwards, the crack will disappear, and a cure be effected; but in the interim the edge of the crust below the crack should be so rasped as not to come in pressure with the shoe.

Sitfasts.—Owing to injuries from the saddle, callosities are apt to form in the skin beneath, which are termed sitfasts.

They should be dressed with some stimulating ointment, until the callous part can be removed, when the sore may be treated in the usual way

Spavin.—A spavin is a swelling on the inside of the hock, and is of two kinds: the first is termed a *bone* spavin, consisting of a bony excrescence; the other a *bog* or *blood* spavin. The former often occasions lameness just before it makes its appearance, and then can be discovered only by feeling the part, which will be

found unusually hot and tender. If a blister is applied at this period of the disease, it will generally prove successful; but when the disease has existed for some time, the cure is much more difficult. In such cases the actual cautery should be applied, and the following day a strong blister; after this two or three months rest (at grass) are absolutely necessary.

The *bog* spavin does not so often occasion lameness as the other, except when a horse is worked hard, which generally causes a temporary lameness, removeable by rest; but it does not often admit of a *radical* cure, for though it is frequently removed by two or three blisters, it generally returns when the horse is made to perform any considerable exertion.

Tying up the vein which passes over the inside of the hock has been considered the most effectual remedy, from a supposition that the lameness was caused by an enlargement of that vessel; this, operation, however, cannot be necessary, since it has been proved that the enlargement of the vein is always an *effect*, and not a *cause* of the disease.

Splents.—Owing to too much weight being frequently placed on the bones, the connecting ligament, inadequate to support the burden, begins to be torn; and nature, to prevent dislocation, brings on inflammation, which produces ossific matter; and by it unites the small and great metacarpal bones together. So far, this process can scarcely be called a disease; the elasticity however, of this part, no longer exists; but it commonly happens that a mere union of the bones is not all; the ossific matter continues to be thrown out, till a considerable body of enlargement takes place, producing pain and lameness. In this case the object should be to remove the extraneous bony matter by exciting its absorption, by the application to the part of the following blistering ointment; when, if a cure is not effected in a few days, it will be necessary to fire the splent, and to blister it again. This diseased enlargement, termed *splent*, from the bone concerned, takes place, in nine cases out of ten, on the inside of the leg, owing to the pernicious habit of turning up the outside heel of the shoe; and which, by throwing a more than ordinary degree of weight on the inside splent-bone, produces the consequences already described.

Blistering Ointment.—Spanish flies powdered, 1 oz.; oil of turpentine, 1 oz.; and hog's-lard, 4 oz. Mix them together.

In applying a blister, the hair of the part should be cut close, and the ointment well rubbed in; the horse's head should also be tied up, to prevent him biting or injuring the blistered surface; and the discharge, when it begins to exude, ought to be gently and frequently removed by means of a sponge and warm water, so as to preserve the skin from blemishes.

Strains.—This is a subject with which every sportsman ought to be well acquainted, since his horses are particularly liable to such accidents. Strains may affect either the muscles, ligaments, or tendons. Muscular strains consist in an inflammation of the muscles or flesh, occasioned by violent and sudden exertion. When ligaments are the seat of this disease, there is generally some part of them ruptured, whereby very obstinate and sometimes permanent lameness is produced; in this case also inflammation is the symptom which first requires our attention. But tendons are the parts most frequently affected, particularly the flexors of the fore leg, or back sinews, as they are commonly termed. Tendinous strains are commonly supposed to consist in a relaxation or preternatural extension of the tendon, and the remedies that have been recommended, are supposed to brace them up again. However plausible this opinion may be, it certainly is very erroneous; indeed it has been proved by experiment, that tendons are *neither elastic nor capable of extension*, and from investigating their structure and economy, we learn, that were they possessed of these qualities they would not answer the purpose for which they were designed. From an idea that a strain in the back sinews depends on a relaxation of the tendons, many practitioners have been apprehensive of danger from the use of emollient or relaxing applications, than which nothing can be more useful at the beginning of the disease.

Tendinous strains consist in an inflammation of the membranes in which tendons are enveloped, and the swelling which takes place in these cases depends on an effusion of coagulable lymph, from the vessels of the inflamed part. Inflammation being the essence of a strain, we are to employ such remedies as are best calculated to subdue it, and should any swelling remain, it is to be removed by stimulating the absorbent vessels to increased action.

Strain of the Shoulder.—This disease is by no means so frequent as it is supposed to be, lameness in the feet being often mistaken for it; the difference, however, is so well marked, that a judicious observer will never be at a loss to distinguish one from the other.

A shoulder strain is an inflammation of some of the muscles of the shoulder, most commonly, I believe, those by which the limb is connected with the body. The lameness which this accident occasions comes on rather suddenly, and is generally considerable. When the horse attempts to walk, the toe of the affected side is generally drawn along the ground, from the pain which an extension of the limb occasions: in violent cases he appears to be incapable of extending it.

When lameness arises from a disease of the foot, it is generally gradual in its attack, unless occasioned by an accidental wound, and does not at all hinder the extension of the limb; an unusual heat and tenderness may also be perceived in the foot, and as the horse stands in the stable, the affected foot will be put forward, that it may bear as little as possible of the weight of the body.

The first remedy to be employed on those occasions is bleeding in the shoulder or plate vein, then give a laxative ball, and if the injury is considerable, let a rowel be put in the chest; by means of these remedies, and rest, the disease will generally be removed in a short time; a cooling opening diet, with perfect rest, will also be necessary. When the inflammation and lameness begin to abate, the horse should be turned into a loose stall, and after a week or two he may be suffered to walk out for a short time every day, but should this appear to increase the lameness, it must be discontinued. The intention of moderate exercise, after the inflammation is in great measure subdued, is to effect an *absorption* of any *lymph* that may have been effused, and to bring the injured muscles gradually into action.

After an accident of this kind, particularly when it has been violent, the horse should not be worked in any way for a considerable time, as the lameness is very apt to recur, unless the injured parts have had sufficient rest to recover their strength. If he can be allowed two or three months' run at grass, it will be found extremely conducive to his recovery, provided he is prevented from galloping or exerting himself too much when first turned out; it is necessary also to choose a situation where there are no ditches in which he may get bogged. With respect to embrocations, and other external applications, they are certainly useless, unless the *external* parts are affected, and then fomentations may be employed with advantage.

Strain of the Stifle.—In this case the stifle joint will be found unusually hot, tender, and sometimes swollen. The remedies are fomentations, a rowel in the thigh, and a dose of physic. When by these means the inflammation of the joint has abated considerably, and at the same time the swelling and lameness continue, the embrocation for strains, or a blister, should be applied.

Strains in the hock joint require the same treatment.

Strain of the Hip Joint (commonly termed Whirl Bone, or Round Bone)—When lameness occurs in the hind leg, the cause of which is too obscure for the farrier's comprehension, he generally pronounces it to be a strain in the round or whirl bone, and with all that affectation of infallibility, so commonly observed in those gentlemen. I have seen several cases of lameness which were supposed to be occasioned by an injury of this part, but after attentive examination an *incipient* spavin was found to be the cause. I would advise therefore in such cases, that the hock joint be carefully examined, and if unusual heat or tendernes be observed on the seat of spavin, it is probable that the lameness arises from that cause, and that it may be removed by the application of a blister. I have met with several horses that had been severely burnt and blistered in the hip, when the hock was evidently the seat of the disease.

Strain of the Flexor Tendon or Back Sinew—A strain of the back sinew depends, as we have before observed, on an inflammation of the membranes in which it is enveloped, and is sometimes complicated with a rupture of the ligaments which are situated immediately under the sinews. When the lameness and swelling are considerable, bleed in the shoulder vein, and give a dose of physic; then let the saturnine poultice be applied, so as to extend from the hoof to the knee, and let it be frequently moistened with the saturnine lotion.—When the inflammation and lameness have abated considerably, and a swelling still remains, apply the embrocations for strains, rubbing it well on the part twice or three times a day; if this does not succeed, recourse must be had to a blister; it will be adviseable also to turn the horse loose into a large stable or barn, and to give him this kind of rest for a considerable time: Should he be worked too soon after the accident, the part is very liable to be injured again, particularly when it has been violent. Should the swelling continue, notwithstanding these remedies have been carefully employed, particularly if it feel callous and hard,

and it be perfectly free from inflammation, it will be necessary to apply the actual cautery; this operation, however, must never be performed while any inflammation remains. These swellings sometimes prove so obstinate, that even repeated blistering and the actual cautery prove ineffectual; as soon, however, as the inflammation which caused them is completely removed, they seldom occasion lameness, yet they will not admit of any violent exertion in the part, and are therefore always an impediment to speed.

Saturnine Lotion.—Acetated lead, 4 oz. vinegar and water, of each 1 pint; mix them well.

Saturnine Poultice.—¼ of a peck of fine bran, to be made into a thin paste with hot saturnine lotion; to this add as much linseed meal as will give it a proper consistence.

Embrocation for Strains.—Oil of rosemary and camphor, of each 2 dr. soft soap, 1 oz. and spirit of wine, 2 oz. To be mixed together.

Another.—Soft soap, spirit of wine, oil of turpentine, and ointment of elder, of each 4 ounces. Mix it together.

Strangles.—This disease generally attacks young horses between the 3d and 5th year of their age, and consists in an inflammation and swelling of the glands under the throat, accompanied with cough and a discharge of white thick matter from the nostrils; sometimes there are likewise a soreness of the throat, and difficulty in swallowing. The inflamed glands commonly suppurate in a short time and burst, discharging a large quantity of matter; when this has taken place, the cough and other symptoms generally go off, the sore gradually heals, and the horse speedily recovers. In some cases the strangles assume a more formidable appearance, are attended with a considerable degree of fever, and the throat is sometimes so much inflamed, that the horse is incapable of swallowing either food or water; but however violent the attack may be, I have always found that by adopting a proper mode of treatment, every unpleasant symptom may be easily removed, and a speedy recovery effected. It is not a very uncommon circumstance for the strangles to attack young horses while at grass, and then they are frequently not perceived until *Nature* has nearly effected a cure.

The approach of strangles may be known by a dulness of countenance, watery eyes, cough, and a slight degree of swelling in the glands under the jaw. As soon as they are discovered, let the hair be carefully clipped off from the inflamed glands and contiguous parts of the throat; let a large poultice be then applied to the throat, in doing which it is necessary to take care that it is so secured as to be constantly in contact with the throat, for unless this is attended to, the poultice will be but of little service. I have generally found that by rubbing a small quantity of some stimulating ointment on the inflamed glands, previous to the application of each poultice, suppuration has been considerably promoted: for this purpose the following formula will be found useful:

Camphor, 2 dr. Oil of Origanum, 1 dr. Spermaceti ointment; 2 oz. Mix.

When matter is completely formed in the glands, which may be known by the tumour becoming larger, and by the skin feeling tense, and somewhat elastic, an opening should be made with a lancet, and its contents evacuated; this plan is certainly preferable to that of waiting until it bursts spontaneously, as the animal is instantly relieved by it, and the cure more speedily effected. To evacuate the matter perfectly, it is necessary to use moderate pressure with the fingers, and when this has been done, let a piece of lint, dipped in digestive liniment, be inserted, for the purpose of keeping the lips of the wound open, and allowing the matter to escape freely; the poultice is to be continued until the swelling is perfectly reduced. When Strangles attack the internal parts of the throat so as to render the horse incapable of swallowing, and particularly if the external swelling is not considerable, it will be adviseable to apply a blister, and keep the bowels open with glysters. It is very necessary, in every case of strangles, to steam the head well, that is, to put hot bran mashes into the manger frequently, so that the horse may inhale the vapours.

It is of consequence to distinguish cases of incipient strangles from common colds; in the latter *bleeding* is an useful remedy, but in the former I believe it does much harm, by interrupting a process of nature. I cannot, by any *argument*, shew why bleeding should be improper in the Strangles; indeed, if our practice were guided by theory only, we should be led to consider it as a case of common inflammation, and consequently adopt that mode of treatment which would tend to remove it most expeditiously and prevent suppuration, and with this view we should have recourse to bleeding and purgatives; *experience*, however, certainly sanctions a different treatment, and has, I think, fully proved the propriety of using

every means for encouraging suppuration. I have seen several hundred cases in which this plan has been pursued, and not one of them terminated unfavourably. Should a cough or any unpleasant symptom remain after the strangles are healed, let the following alterative ball be given every morning, until moderate purging is produced, and if it is found necessary, let it be repeated after an interval of four or five days. It is almost superfluous to add, that great attention must be paid by the groom; the head, neck, and chest, as well as the body, should be cloathed, warm water should be given frequently in small quantities, a large quantity of litter should be allowed, and hand-rubbing to the legs should never be omitted.

Alterative Ball.—Barbadoes aloes, 1½ dr. Emetic tartar and Castile soap, of each, 2 dr. To be made into a ball for one dose.

Suppression of Urine.—Horses are often attacked with a difficulty in staling or making water, sometimes amounting to a total suppression of that excretion; this most commonly arises from spasm in the neck of the bladder, or from hardened excrement in the rectum or latter part of the intestines. When this happens let glysters of warm water be injected until all the hard excrement is discharged, then give the following ball.

Nitre, 1 oz. Camphor, 2 dr. Linseed meal and syrup enough to form the ball for one dose.

Should there be any appearance of fever, or should the horse appear to feel pain when the loins are pressed upon, it is probable that the kidneys are inflamed, —in such cases the ball would be improper (vide inflammation of the kidneys.

Surfeit.—This absurd term is given by farriers to a disease of the skin, consisting in small tumours or knobs which appear suddenly in various parts of the body, sometimes in consequence of drinking largely of cold water, when the body is unusually warm: it appears frequently without any manifest cause. It may be easily cured by bleeding moderately, or giving a laxative ball; sometimes, indeed, it goes off without any medical assistance. There is another disease of the skin of the same name, which is generally more obstinate, and attacks horses that are hide-bound and out of condition; in this a great number of very small scabs may be felt in various parts of the body; the horse is frequently rubbing himself, and sometimes the hair falls off from the parts which he rubs. This complaint approaches to the nature of mange, and requires the same treatment, assisted by a generous diet, good grooming, and regular exercise.

Thorough-Pin.—By this term is meant a swelling both on the inside and outside of the hock joint. When one of the tumours is pressed with the fingers, the fluid which it contains is forced into that on the opposite side. From this communication between the two swellings the disease has probably obtained its name.

It is generally a consequence of hard work, and therefore difficult to cure; the only remedies are blisters and rest.

Thrush.—This disease consists in a discharge of fœtid matter from the cleft of the frog, which part is generally rotten and so soft as to be incapable of affording sufficient protection to the sensible frog which it covers; hence arises that tenderness of the foot which is so often observed. When this complaint attacks the fore feet, it is seldom, if ever, an *original* disease, but merely a *symptom* or an *effect*. The cause is generally a contraction of the horny matter at the quarters and heels, by which the sensible frog is compressed and inflamed; the discharge which takes place is a consequence of this inflammation, and may be considered as an ineffectual effort of nature to cure it. The discharge, however, certainly diminishes the inflammation, and prevents it from becoming so considerable as it otherwise would; for it often happens when it has been stopped by the injudicious application of astringents, or when it ceases spontaneously, that the inflammation becomes violent, extends to the other parts of the foot, and occasions severe lameness, which generally is relieved or removed by a return of the discharge: but we are not to infer from this that an attempt to cure thrushes is improper; it only shews that it is necessary in the first place to remove the *cause* of the disease. With this view the quarters are to be rasped, and the hoofs kept constantly moist by making the horse stand in clay some part of the day, taking care to keep the frog dry by means of tar When by these means we have succeeded in removing in some measure the compression and consequent inflammation of the sensible frog, it will be adviseable to apply some astringent to the frog, which, if assisted by pressure and tar, will render that part firm and solid, and the discharge will of course cease when the inflammation leaves the sensible frog.

The best astringent for this purpose is a solution of white or blue vitriol,

alum, &c. There are some cases, however, of thrushes which though occasioned by compression of the sensible frog, it is difficult, if not impossible, to eradicate. I have examined feet with this disease after death, and have found the concave part or cleft of the *sensible* frog in a state of ulceration, which of course rendered it incapable of secreting horny matter, and proved a constant source of thrushes.

With respect to those Thrushes which attack the hind feet, and which sometimes, though rarely, happen also in the fore feet, independently of the above cause, a different treatment is required. When the discharge has existed for a considerable time, by stopping it hastily we frequently produce inflammation and swelling of the legs; still it is necessary to check the disease, since, if neglected, it sometimes degenerates into that dangerous disease termed canker. It is adviseable, therefore, in such cases, to keep the bowels open by the following laxative ball, given every morning until the desired effect is produced, and repeated occasionally.—The best application for the frog is tar, and one of the above astringents; other remedies, however, have been strongly recommended, among which are powdered lime, Mel Egyptiacum, tincture of Myrrh, &c. and other Astringents. This treatment will be greatly assisted by two or three hours exercise every day, and frequent hand-rubbing to the legs.

Laxative Ball.—Take aloes, 2 dr. Castile soap, 3 dr. To be made into a ball for one dose.

Warbles. See Saddle Galls.

Wind-Broken. See Broken Wind.

Windgalls.—Consist in an enlargement of the mucous sacs, which are placed behind the flexor tendons for the purpose of facilitating their motion The swelling appears on each side the back sinew, immediately above the fetlock joint; if punctured they discharge a fluid resembling joint oil; indeed, they frequently communicate with the cavity of the joint, and therefore cannot be opened without danger of producing an incurable lameness. Blisters are the only applications likely to be of service, and these seldom effect a cure unless assisted by rest. This complaint does not often occasion lameness, and is therefore seldom much attended to; but, as it is almost always a consequence of hard work, and often renders a horse unfit for much labour, it diminishes his value considerably.

I have sometimes applied rollers, or bandages to the legs with good effect, keeping them constantly moist with the following embrocation:

Muriate of ammonia, 1 oz. muriatic acid, ½ oz. water, 1 quart. Mix.

Worms.—There are three kinds of worms found in horses. The most common and mischievous reside in the stomach, and are named Bots. They are of a reddish colour, and seldom exceed three-fourths of an inch in length: at one extremity they have two small hooks, by which they attach themselves, and the belly seems to be covered with very small feet. They are found adhering to the coat of the stomach, and do great injury to this important organ, keeping up a constant irritation, and thereby occasioning emaciation, a rough staring coat, hide-bound, and a cough. I have met with several instances of their destroying the horse, by ulcerating the stomach in a considerable degree; and cases are recorded where they have penetrated quite through the stomach. It is astonishing with what force these worms adhere, and how tenacious they are of life: they have been found to resist the strongest poisons; nor have we yet discovered any medicine capable of destroying them, or of detaching them from their situation. It seems probable that this worm, like the caterpillar, undergoes several changes; it is said to be originally a fly, which depositing its eggs in the horse's coat, causes an itching which induces him to bite the part; in this way he is supposed to swallow some of the eggs, which, by the heat of the stomach, are brought to maturity, and produce bots. When the bots are fit to assume the chrysalis state, they are spontaneously detached, and gradually pass off with the fœces. This is the most rational account we have of their production.

It has been asserted that the fly from which bots are produced, crawls into the anus of horses, and deposits its eggs there; that the worms, when hatched, soon find their way *farther up the intestines*, and often penetrate into the stomach. This account is literally copied by a late writer *(Ryding)* on Veterinary Pathology; but, it appears to me rather strange, that any one who has considered the structure of the horse's intestines, should, for a moment give credit to it. It seems impossible indeed, for this worm to crawl from the anus to the stomach, and as far as my observation goes, they are never found residing in the intestines; sometimes we find two or three, but they are evidently proceeding towards the anus to be expelled. I have before observed, that I am not acquainted with any medi-

cine that is capable of detaching or destroying these worms, though I have frequently tried the strongest mercurial preparations, and many powerful medicines.

I have tried the yellow emetic mercury, or vitriolated quicksilver, as recommended by the writer just mentioned, as well as every other mercurial preparation, but never saw a single bot expelled by them!

A pint of Castor oil, given after this dose of mercury, would prove useful.

The next worm we have to describe, is very slender, of a blackish colour, and seldom exceeds two inches in length; they are never found in the stomach, and very rarely in the small intestines, the largest part of the canal being generally the place of their residence: here they prove a constant source of irritation, occasioning loss of condition, a rough unhealthy looking coat, and frequently a troublesome cough. A variety of alterative medicines have been proposed for the destruction of these worms, and some of them are supposed to be infallible; I believe, however, that none of them are possessed of much efficacy, and ought not therefore to be depended upon.

The following are the Alteratives to which I allude:—Savin, rue, box, Æthiops mineral, antimony, sulphur, emetic tartar, calomel, and vitriolated quicksilver; the two last, if given with aloes, so as to purge briskly, and particularly the calomel, are excellent remedies: but given merely as Alteratives, they do no good.

I have generally found the following Ball very effectual, giving, the preceding night, from half a drachm to a drachm of calomel. I have often mixed the calomel with the ball, and found it equally efficacious; the former method, however, is generally preferred.

Ball.—Barbadoes aloes, 6 dr. powdered ginger, 1½ dr. oil of wormwood, 20 drops, prepared natron, 2 dr. Syrup enough to form the ball for one dose.

It is often necessary to repeat this medicine; but there should always be an interval of ten days between each dose.

The third kind of worm is of a whitish colour, frequently seven or eight inches in length, and generally found in the lower part of the small intestines. These worms are not so common as the other, but appear to consume a considerable quantity of chyle, or the nutritious parts of the food; they may be got rid of by the same means that we have recommended for the small blackish worm.

We may always be satisfied of the existence of worms in the intestines, when a whitish or light straw coloured powder is observed immediately beneath the anus: I have sometimes succeeded in destroying worms, by giving one drachm and a half of aloes every morning, until purging was produced

Wounds.—The first necessary operation in wounds is to remove carefully all dirt or other extraneous matter, and if the wound be made with a clean cutting instrument, and not complicated with bruising or laceration, the divided parts are to be neatly sewed together. Where it can be done, a roller kept constantly moist with the saturnine lotion, diluted with an equal quantity of water, is to be applied, in order to assist in retaining the parts in their situation; this roller is not to be removed for several days, that the divided parts may have time to unite, and that the wound may heal by the first intention, as surgeons term it, unless considerable swelling and inflammation come on, when it becomes necessary to remove the roller, and apply fomentations. This kind of union, however, can seldom be accomplished in horses, from the difficulty of keeping the wounded parts sufficiently at rest, and from their wounds being generally accompanied with contusion or laceration; yet it should be always attempted where it appears at all practicable. Fomentations and warm digestives then become necessary, in order to promote the formation of matter in the wound: should considerable swelling and inflammation arise, moderate bleeding near the affected part, and a laxative medicine, or even a dose of physic, are strongly to be recommended, and a poultice, if the situation of the part be such as to admit of its application, will be found of great use. As soon as the swelling and inflammation shall have been removed the fomentations and poultice are no longer necessary, and the digestive ointment only is to be applied: should the wound appear not disposed to heal, discharging a thin offensive matter, apply the detergent lotion previous to the digestive ointment. When the granulations become too luxuriant, that is, when what is commonly termed proud flesh, makes its appearance, the caustic powder is to be sprinkled on the wound.

Slight wounds generally heal with very little trouble, and sometimes without the interference of art; and it is from this circumstance that many nostrums have acquired unmerited reputation. In wounds of this kind, tincture of myrrh, or compound tincture of bezoin may be used.

Whenever a considerable blood-vessel is wounded, and the hemorrhage is likely to prove troublesome, our first object is to

stop the bleeding; which, if the wound be in a situation that will admit of the application of a roller or bandage, may be easily effected; for pressure properly applied is generally the best remedy on those occasions. and far more effectual than the most celebrated styptics. In some cases it becomes necessary to tie up the bleeding vessels; this is rather a difficult operation, and not often necessary.

Punctured Wounds, or such as are made with sharp-pointed instruments, are generally productive of more inflammation than those that have at first a more formidable appearance: and if such wound happen to penetrate into a joint or the cavity of the chest or belly, the worst consequences are to be apprehended, unless it be skilfully treated.

When a joint has been wounded, the synovia or joint oil may be observed to flow from the wound. The first thing to be done in those cases, is to close the opening that has been made into the joint, for as long as it remains open the inflammation will go on increasing, and the pain will be so violent as to produce a symptomatic fever, which has often proved fatal. The most effectual method of closing the wound is by applying the actual cautery; this will appear probably a very strange remedy to those who have not seen its effect, yet it is certainly the most efficacious that can be employed, although only applicable where the wound is of the punctured kind and small; for when a large wound is made into the cavity of a joint, and particularly if it is of the lacerated kind, it is impossible to close it effectually, and death is frequently the consequence. As soon as the opening has been closed, it is of importance to guard against the inflammation that may be expected to arise, or to remove it if already present. For this, bleeding and purging are the most effectual remedies. A rowel in any convenient part near the affected joint will be found useful also. Should the joint be much swollen, the blister, No. 2, will prove very efficacious, and far superior to fomentations or poultices.

Wounds about the foot, from stubs, over-reaching, &c. often prove troublesome when neglected; as soon as they are perceived, care should be taken that no dirt get into them—the detergent lotion and digestive ointment are the most useful applications on those occasions.—When the foot is wounded in shoeing, the nails being driven into the sensible parts, the compound tincture of benzoin is to be applied. When their tendons or their membranes are wounded, considerable inflammation is likely to take place, which is to be removed by fomentation and the saturnine poultice; purging is also of great use in those cases, and when the wound is large, and inflammation runs high, bleeding likewise may be necessary.

In extensive, lacerated, or contused wounds, the inflammation sometimes terminates in mortification (vide inflammation); in such cases fomentations are to be frequently applied, and the horse's strength supported by means of malt, and the cordial ball for mortification.

Having thus treated on most, if not all the diseases of horses, with the best modes of cure, adapted to each, we shall now give an approved treatise on Physic, containing various formulæ for Purges, Diuretics, Alteratives, Laxatives, Blisters, Fomentations, Poultices, Rowels, and Glysters, taken from a work published by a Professor of the Veterinary Art, viz.

Of Physic—In purging horses great care and attention are necessary, their bowels being particularly irritable, and liable to inflammation. The physic commonly given is certainly too strong; and I am convinced that many horses have been destroyed by the immoderate doses that have been recommended by writers on Farriery; when this happens, the mischief is generally attributed to the coarseness or impurity of the medicine, and the Druggist is undeservedly censured. A modern author has ingeniously availed himself of this prejudice, to explain the violent effects which his Carthatic prescriptions have sometimes produced. I must presume, however, to suggest, that these effects were more probably occasioned by the excessive quantity than by the impurity of the purgative ingredients.

It is adviseable to prepare a horse for physic by giving him bran mashes for a day or two; this will gently relax the bowels, and remove any indurated fœces that may be lodged in them, it will also tend to facilitate the operation of the medicine.

When a horse is purged for the first time, it is prudent to give a very moderate dose; were the common quantity given to one of weak, irritable bowels, there would be danger not only of producing great debility, and thereby of counteracting the intention of the medicine, but likewise of destroying the animal, by bringing on an inflammation of the bowels; and this is by no means an unusual occurrence. Should the first Ball not operate sufficiently, a stronger may be given after an interval of a few days.

The morning is the best time for giving

a purgative, the horse having previously fasted two or three hours. If he is disposed to drink after taking the Ball, give a moderate quantity of warm water, which will promote its solution in the stomach, and consequently expedite the operation: during this day the horse is to be kept in the stable, and fed with bran mashes and a moderate quantity of hay; he may be allowed also to drink plentifully of warm water, and if he refuses it in this state, let it be offered nearly cold. The following morning he is to be exercised, and at this time the medicine will generally begin to operate. Should the purging appear to be sufficient, he need not be taken out a second time, but when the desired effect does not readily take place, trotting exercise will tend to promote it; during this day also, he is to be carefully supplied with bran mashes and warm water: warm cloathing, more particularly when out of the stable, must not be omitted; the next day the purging will generally have ceased, and then a small quantity of corn may be allowed. When physic does not operate at the usual time, the horse appearing sick and griped, relief may generally be obtained by giving a glyster of water gruel, and making him drink freely of warm water, assisted by exercise. When the purging continues longer than usual, and the horse appears to be considerably weakened by the evacuation, let the astringent ball be given.

It will be observed, perhaps, that some ingredients, commonly thought necessary in physic, have been omitted in the following formulæ.—These medicines have been proved, however, to be perfectly useless. Jalap, though given to the amount of four ounces, will produce very little purgative effect upon a horse, nor will salts or cream of tartar; rhubarb, however large the dose, will not operate as a purgative, though it may be useful in moderate doses as a stomachic.

No. 1—Barbadoes aloes, 5 dr. prepared natron, 2 dr. aromatic powder, 1 dr. oil of caraways, 10 drops. Syrup enough to form the Ball, one dose.

No. 2—Barbadoes aloes, 7 dr. Castile soap, ½ oz. powdered ginger, 1 dr. oil of caraways, 10 drops. Syrup enough to form the Ball, one dose.

No. 3—Barbadoes aloes, 1 oz. prepared natron, 2 dr. aromatic powder, 1 dr. oil of anise-seeds, 10 drops. Syrup enough to form the Ball for one dose.

The Ball, No. 2, I have generally found sufficient for strong horses, and have scarcely ever had occasion to go farther than No. 3.—Should any one, however, be desirous of stronger medicine, it may readily be procured by adding one or two drachms of aloes, or one drachm of calomel to the Ball No. 3; but I must not omit to observe, that there appears to me to be a considerable danger in making the addition.

Diuretics—These are medicines which by stimulating the kidneys, increase the secretion of urine. The following formulæ I have found both convenient and efficacious.

No. 1.—Castile soap, 4 oz. powdered rosin and nitre, of each, 2 oz. oil of juniper, ½ oz. Linseed powder and syrup enough to give it a proper consistence, to be divided into six Balls for strong, or eight for weak delicate horses.

No. 2—Castile soap, 4 oz. Venice turpentine, 2 oz. Powdered anise-seeds enough to give it a proper consistence, to be divided into six balls.

Alteratives.—These are medicines which produce their effects almost insensibly; the following formulæ will be found efficacious:

Alterative Powders.—No. 1. Levigated antimony, 6 oz. flower of sulphur, 8 oz. Mix for eight doses.

No. 2.—Powdered rosin, 4 oz. nitre, 3 oz. tartarized antimony, 1 oz. Mix for eight doses.

No. 3.—Unwashed calx of antimony, 2 oz. calomel, 2 dr. powdered anise-seeds, 4 oz. Mix for eight doses.

Should a Ball be thought more convenient than a powder, the change may be easily made by the addition of syrup and linseed powder.

A dose of the Alterative Powder should be given every evening with the corn until the whole quantity (that is eight doses) are used.

Laxatives—This term is applied to opening medicines, that operate very mildly, and produce so gentle a stimulus upon the intestine, as merely to hasten the expulsion of their present contents, without increasing their secretions. Castor oil seems to be the best medicine of this kind, though the oil of olives and linseed, will produce nearly the same effect; the dose of the former is about a pint, but the latter may be given to a pint and a half. When a laxative ball is required, the following will be found useful:

Succotrine aloes, ½ oz. Castile soap, 3 dr. Syrup enough to form the Ball for one dose.

Blisters—Previous to the application of a blister, the hair should be cut from the part as closely as possible, the blistering ointment is to be well rubbed on it, and afterwards a small quantity is to be spread over the part with a warm knife. When

the blister begins to operate, as the horse is very apt to bite the part, which, if suffered, might produce a permanent blemish; it is necessary therefore to guard against this accident by putting what is termed a cradle about his neck, or by tying him up to the rack. When the legs are blistered, the litter is to be entirely swept away, as the straw might irritate the blistered parts.

Blistering Ointment.—No. 1. Spanish flies, powdered, ½ oz. oil of turpentine, 1 oz. ointment of wax or hog's lard, 4 oz. Mix.

No. 2. Oil of turpentine, 1 oz. To which add gradually, vitriolic acid, 2 dr. hog's lard, 4 oz. Spanish flies, powdered, 1 oz. Mix.

No. 3. Common tar, 4 oz. vitriolic acid, 2 dr. oil of origanum, ½ oz. hog's lard, 2 oz. Spanish flies, powdered, 1½ or 2 oz. Mix.

Remark.—The Blister No. 3, is remarkably useful in removing enlargements of the back sinews or windgalls. Sublimate is often recommended as an ingredient in blisters, but it is very apt to ulcerate the skin, and leave a permanent mark or blemish; I have therefore omitted it in the above formulæ; but in cases of bone spavin, in which severe blistering is necessary, it may be employed with advantage.

Fomentations.—Fomentations are commonly made by boiling wormwood, southernwood, camomile flowers, and bay leaves in water, so as to make a strong decoction, which being strained off, is to be applied as hot as it can be, without giving pain to the animal, by means of large flannel cloths. The efficacy of fomentations depends in great measure on their use being continued for a considerable time together, and being frequently repeated.

Poultice.—The following mixture will be found useful as a common poultice: fine bran 1 quart; pour on it a sufficient quantity of boiling water, to make a thin paste; to this add of linseed powder enough to give it proper consistence.

Rowels.—When these are used with a view of relieving internal inflammation or fever, it will be found useful to apply blistering ointment instead of turpentine, or the digestive commonly made use of, for this will produce a considerable degree of inflammation in a short time.

Glysters.—A variety of compositions have been recommended for glysters, by those who have written on the subject, there being scarcely an article in the Materia Medica, that has not been occasionally employed in this way. I have found, however, from considerable experience, that for a common glyster, water-gruel is as efficacious as the most elaborate composition; when that cannot be readily procured, I have been in the habit of using warm water, and without perceiving any difference in the effect. Where a purgative glyster is required, from four to eight ounces of common salt may be added; and if an anodyne be wanted, or an astringent, let half an ounce of opium be dissolved in a quart of water-gruel. The best method of administering glysters is, by means of a bladder and pewter pipe. If a glyster is employed for the purpose of emptying the large intestines, or of purging, the quantity of liquid should not be less than a gallon, or six quarts: but, when it is used as an anodyne or astringent, from a quart to three pints of liquid will be sufficient.

Alteratives.—Medicines that gradually change the system from a diseased to a healthy state; the medicines commonly used as alteratives, are given in very small doses, so that their effect is scarcely perceptible; nor do they prevent a horse from continuing his usual work, or render it necessary to make any alteration in his diet. They are of three kinds; namely, laxative, diuretic, and diaphoretic.

Laxative Alteratives.—No. 1. Barbadoes aloes, ten drachms; Castile soap, one ounce; aniseed, powdered, one ounce and an half; oil of cloves, twenty drops; and syrup enough to form the mass for four balls, one to be given every morning, until the bowels are moderately opened.

No. 2.—Barbadoes aloes, one ounce; calomel, one drachm and an half; golden sulphur of antimony, half an ounce; powdered carraway seeds, one ounce; and syrup enough to form the mass to be divided into four balls, and given like the preceding No. 1.

No. 3.—Flower of sulphur, six ounces; tartarized antimony, six drachms; mix for six doses. This may be given in the form of powder daily: few horses will refuse it in their corn.

No. 4.—Liver of antimony, three ounces; cream of tartar, four ounces: Mix for six doses; one to be given daily, or until the bowels are properly opened.

Diuretic Alteratives.—No. 1. Yellow rosin, powdered, six drachms; nitre, half an ounce: Mix for one dose, to be given daily.

No. 2.—Flower of sulphur, and liver of antimony, of each half an ounce; nitre, three drachms: Mix for one dose, to be given daily.

No. 3.—Prepared natron, or soda, reduced to powder by exposure to the air, one ounce; Castile soap, six drachms;

powdered resin, two ounces; liquorice powder, half an ounce; Barbadoes tar, enough to form a mass for six balls, one to be given daily.

Diaphoretic Alteratives.—No. 1. Antimony, finely levigated, one ounce: To be given daily in the horse's corn.

No. 2.—Unwashed calx of antimony, three drachms; powdered aniseseed, one ounce and an half: Mix for two doses, one to be given daily.

No. 3.—Tartarized antimony, one drachm; strong muriat of quicksilver, twelve grains; arrow root, powdered, half an ounce; grains of paradise, two drachms; oil of caraway, ten drops; and syrup enough to form the ball for one dose.

Remark.—This is an excellent remedy in obstinate cutaneous complaints; as surfeit, farcy, &c. The quantity of muriat of quicksilver should be gradually increased; but, if it occasion sickness, griping or purging, or if it make the mouth sore, it must be discontinued a short time, and afterwards given in diminished doses. This remark applies to all the preparations of mercury, when given as *alteratives.*

Solid Caustics, Strong.—No 1. Actual Cautery, or Red Hot Iron. This remedy though apparently so severe, is often productive of the happiest effects, when all other applications have failed.

No. 2. Pure Potash, with lime.

3. Nitrated silver or lunar caustic.

4. Nitrated copper.

Mild caustics solid.

No. 1. Acetated copper or distilled verdigris.

No. 2. Vitriolated copper, or blue vitriol.

No. 3. Red nitrated quicksilver, or red precipitate.

No. 4. Burnt alum.

5. Common verdigris.

Remark—The strong caustics are generally sold in a convenient form for application; but the mild require to be finely powdered and sprinkled on the ulcer. They are sometimes mixed with digestive ointment to increase their power.

Cordial Balls—No. 1. Powdered carraway seeds, six drachms; ginger, 2 dr.; oil of cloves, 20 drops. Honey or treacle enough, to form the ball for one dose.

No. 2. Powdered aniseed six drachms; powdered cardamoms, two dr.; powdered cassia, one dr. Essential oil of Cummin seed, twenty drops. To be made into a ball with honey, for one dose.

No. 3.—Powdered carraway seeds half an ounce; grains of paradise, 3 drachms; aromatic powder, 1 drachm, oil of carraway, 20 drops. To be made into a ball with honey for one dose.

Detergent Lotions—No. 1. Vitriolated copper, one ounce; vitriolic acid, twelve drops; water, four ounces. Mix.

No. 2.—Nitrous acid, one ounce; vitriolated copper, half an ounce; water, eight ounces. Mix.

Digestive Ointment—This ointment is used to promote suppuration in wounds, or ulcers:—

Hogs lard, four ounces; bees wax, one ounce; Venice turpentine, three ounces; red nitrated quick silver, finely powdered, two ounces. Melt the three first over a slow fire, and while the mixture is liquid, but nearly cold, stir in the powder.

Goulard Lotion, extract of lead—This is made from litharge and vinegar, by simmering them together over a gentle fire, until the vinegar has dissolved as much as it is capable of. It is a very useful application in cases of external inflammation, and may be used either as a lotion, or in the form of poultice.

Goulard lotion, is made, by mixing half an ounce of the extract to a pint of water, —When intended for the eyes, there should be not less than a quart of water.

Goulard poultice, is made by mixing as much of the lotion, with bran, Linseed meal, or any proper materials, for poultice, as will give it a proper consistency.

Eye Waters.—No. 1. Extract of saturn, one tea spoonful; camphorated spirit, two tea spoonfuls; elder flower water, half a pint: Mix.

No. 2.—Vitriolated zinc, one drachm; water, one pint: Mix.

No. 3.—Vitriolated zinc and acetated lead, of each one drachm; water, twelve ounces: Mix.

No. 4.—Opium, one drachm; water, four ounces: Mix.

Saturnine Lotion. See *Goulard Lotion.*

Saturnine Poultice. See *Goulard Poultice.*

In the commencement of this treatise, we premised that our limits would not admit of a complete anatomical description of the horse. Desirous, however, to give as full an illustration of this important science as a regard to the nature of our work will admit, we have given three plates, (see plates, title *Fartiery,*) with full explanations; namely, No. 1, exhibiting the complete skeleton of a horse, shewing every bone. No. 2, representing the intestines of the horse, as they appear in their natural situation, when the abdomen is laid open. No. 3, shewing the foot in its various forms, and containing, also, drafts of some of the most modern and approved shoes.

FARRIERY.

Plate 3.

Fig. 1.

Fig. 7

Fig. 2.

Fig. 8

Fig. 6.

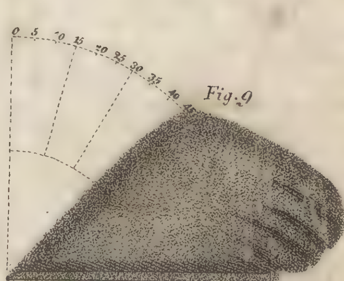


Fig. 9

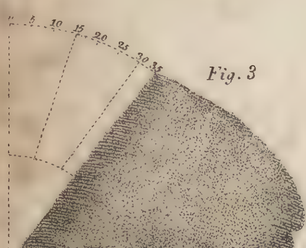
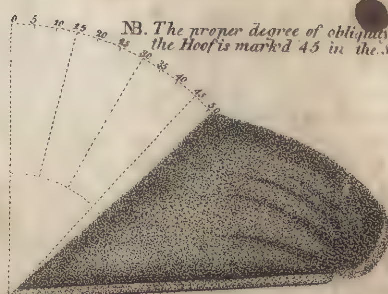


Fig. 3

NB. The proper degree of obliquity in the Hoof is mark'd 45 in the Scale.



And as much of the lameness to which this useful animal is subject, proceeds from negligence in shoeing, we beg leave to impress upon all horsemen the importance of the following observations on that subject.

On the Practice of Shoeing.—Previously to giving directions for the proper accomplishment of this important object, it will be necessary to premise, that the mode of shoeing most commonly practised has a destructive tendency, and produces such a variety of diseases, that we seldom meet with a foot that has not lost, in a greater or less degree, its original shape; it must be obvious, therefore, that one kind of shoe cannot with propriety be recommended for general application, and that it is necessary on all occasions to adapt it carefully to the state of the foot. This constitutes the most difficult part of the art of shoeing, and from neglecting this precaution, shoes of the best form have often occasioned lameness.

In fig. 1, plate 3, is represented a colt's hoof in a state of nature, of which no part has ever been cut away, nor ever been shod; this we have given as a standard of perfection, from which the goodness of feet in general may be judged of; for surely no one will hesitate for a moment in admitting that the natural form is the best it can possibly possess.

In fig. 2, of the same plate, is shown a perfect foot, properly prepared for the shoe; in this foot, the superfluous horn has been cut away, and an even surface made for the shoe to bear upon.

If we examine the feet of an hundred colts, it will be found that more than ninety of them are of the same form. It is true that some may have grown more luxuriantly than others, whereby the crust will be deeper, and the bottom part may have been partially broken, so as to give the foot a ragged and uneven appearance, still the essential shape is the same, and when this superfluous horn has been removed, it will be found that the bottom of the foot will be nearly circular, the sole concave, the bars distinct, the frog and heels open and expanded.

In preparing a horse's foot for the shoe, the lower part is to be reduced, when luxuriant, which is generally the case, more particularly at the toe, and this is to be done by means of a buttress or rasp: the loose scaly parts of the sole are likewise to be removed, so as to preserve its concavity, and a small cavity is to be made with a drawing knife, between the bar and crust, to prevent the shoe from pressing on that part, and occasioning corns; it is however necessary in doing this, to take particular care that the connection between the bar and crust is not destroyed or weakened, which would of course render the bar useless.

The junction of the bar and crust affords a firm bearing for the heel of the shoe, and is to be rasped perfectly flat, and so low as to be exactly on a level with the frog, that they may bear equally on a plain surface, before the shoe is applied; indeed, the whole of the bottom of the crust is to be made perfectly flat and even at the same time with the rasp, that the shoe may bear equally on every part of it. Farriers should never be allowed to do this by means of a hot shoe, which is too freqently the case. If any ragged parts are observed in the frog, they are to be carefully removed with a knife, for, if suffered to remain, they might afford a lodgement for dirt and gravel. Thus do we prepare a foot for the shoe, and to a foot of this description, I mean one that is sound and perfect, or that has not suffered any material alteration in its form from improper shoeing, the shoe (fig. 8, plate 3) is to be applied.

The toe of a shoe, for a middle sized horse, is about an inch in width, and half an inch in depth or thickness; the heels about half an inch in width, and three eighths in depth. The wearing part of the toe is to be made of steel, and it may be observed, that the nails are brought very near to the toe, but not quite round it; for when that is done, there must also be a groove made, which considerably weakens that part, and almost all horses wear principally at the toe. Both surfaces of the shoe are perfectly flat, and the heel of the shoe rests upon the junction of the bar and crust, beyond which it should never extend.

It will be supposed, perhaps, that a shoe which is flat on that surface next the foot, will be apt to produce lameness by pressing on the sole; but let it be recollected, that this shoe is recommended only for a sound foot, in which the sole is always a little concave, so that it cannot possibly receive any pressure from a flat shoe: it may be said also, that when the nails are placed so far from the heels, the shoe will not be sufficiently secure, and will be frequently loosened; but as the shoe bears equally on every part of the crust, this objection cannot have any weight. It must be granted, however, that when a foot is pared in the common way, that is, when the heels have been *opened*, and the shoe so applied, that nearly an inch of the heel has no bearing upon the crust; that if the nails were placed so far from the heels, as I have recommend-

ed, the shoe would be very insecure; for, as much of it as had no bearing upon the crust, would operate occasionally as a lever in raising the nails, and consequently the shoe would frequently be loosened. Farriers therefore find it necessary, when the foot has been thus pared, and the shoe applied in this way, to place the nails in the quarters, by which the shoe is certainly rendered more secure than it would be, had they been placed nearer the toe.

Many disadvantages, however, attend this method. In the first place, by placing the nails in the quarters, they prove a considerable obstacle to the expansion of the heels, and as the crust is generally much thinner at the quarters than at the toe, the sensible parts are more liable to be wounded; but this does not apply to the hind feet, in which the crust of the quarters is generally thicker than that of the toe. When a horse over-reaches, if any part of the shoe has no bearing upon the crust, it is very liable to be struck by the toe of the hind foot, and shoes are often forced off in this way; to this may be added, the insecurity of such a shoe when a horse is rode on a deep or heavy ground.

It will probably be observed of the shoe which I have recommended, that it is inconsistent with the principle which has been laid down respecting the necessity of the frog's receiving pressure. I believe it is an incontrovertible fact, that unless the frog receives a certain degree of pressure, it will become soft and incapable of affording sufficient protection to the sensible frog which it covers; that the heels will gradually contract, and the natural form of the foot will be destroyed, for I have proved by experiment, that the bars alone are not sufficient to *prevent* contraction, though they certainly oppose it with considerable force; but it does not follow from this, that it is necessary for the pressure to be *constant*, nor do I believe that a shoe which allows the frog to bear upon the ground, when he stands upon a plane hard surface, can be always applied, even to *sound* feet, without inconvenience. There can be no doubt, that a horse in a state of nature has his frog almost always in contact with the ground, and then of course he feels no inconvenience from it; but when burthens are placed upon his back, and he is driven about upon hard roads, he is certainly in very different circumstances, and if the frog in such cases were constantly exposed to this severe pressure, it would sometimes, I believe, occasion lameness.

In the foot, prepared for the shoe, (fig. 2, plate 3,) the frog and heels are on a level, and if placed on a plane hard surface, would bear equally; by applying the shoe, (fig. 8, plate 3,) the frog would be raised three-eighths of an inch from the ground; so that when the horse is going upon a hard surface, where he would be most liable to feel inconvenience from the pressure on the frog, it receives none; but upon soft yielding ground the frog certainly receives pressure, and without giving the animal any pain. To a horse that travels or works regularly, and is occasionally taken upon soft ground, I believe the pressure the frog receives in this way, is quite sufficient to preserve the foot in a state of health; but when a horse is kept almost constantly in the stable, standing upon hot litter, particularly in hot and dry weather, his feet will certainly be undergoing an alteration in their form, and will be in a progressive state towards disease.

In those cases, however, contraction of the hoof may be effectually prevented by means of the patent artificial frog, invented by Mr. Coleman, professor of the Veterinary College. By this ingenious contrivance a horse's frog may receive sufficient pressure, in whatever circumstances he may be placed, to prevent contraction, and keep the foot sound and healthy, without the inconvenience of wearing thin heeled shoes; but it must be remembered that whenever the frog is much exposed to pressure, whether it be by applying the patent frog, or by the thin heeled shoe, and reducing the crust at the heels, it is necessary the quarters and heels should possess a proper degree of pliancy; if they are rigid and inflexible, it is evident that the sensible frog and cartilages would be placed between two fixed points, and they would consequently be bruised and inflamed. I have indeed seen several cases of lameness produced in this way; whenever the hoof, therefore, appears to be too dry and strong, or to have lost its natural elasticity, it is necessary to rasp the quarters and keep the whole hoof moist, either by applying several folds of flannel round the coronet, constantly wetted, or by making the horse stand in soft clay, four or five hours during the day; by these means the natural flexibility of the horn would be restored, and the heels and quarters yield in a small degree, whenever the horse's weight was thrown upon the frog.

Having said as much as appears to be requisite of the method of shoeing a sound foot, I shall proceed to describe those diseases of the foot which render a different kind of shoe necessary. In the first place it will be proper to observe, that when a

horse, even with a sound foot, has worn shoes that are very thick, or turned up at the heels, particularly if at the same time the crust at the heels has been suffered to grow so high that the frog is kept at a considerable distance from the ground, it would be very improper to reduce the heels suddenly, so as to allow the frog to receive pressure, since the back sinews would in that case be injured, and lameness might ensue. In feet of this description it is necessary to remove from the toe all that can be done without exposing the part too much, and to lower the heels gradually: the toe of the shoe should be made rather thin, and of the best steel.

The shoe for draught horses should be made flat on both surfaces, provided the sole is of a proper form and thickness, but if flat or convex, and consequently too thin, which is often the case in horses of this description, the internal surface of the shoe must be concave; still the external surface should be flat, for the convex shoe, which is commonly used for draught horses, prevents them from treading securely, and renders them incapable of exerting the whole of their strength.

Of the Age of a Horse—The age of a horse may be discovered by certain marks in the front teeth of the lower jaw, and the tushes, until the eighth year, about which time they are generally worn out. An experienced person, can however, after that period, judge of the age, with some degree of accuracy, by the countenance and general appearance of the animal, as well as by the length of the teeth, and form of the tushes.

Between the second and third year, a colt begins to change his sucking teeth, as they are termed, for others of a larger size, and of a different form and colour. The sucking teeth are small, of a delicate white colour, some of them perfectly smooth on the upper surface; others have a small narrow cavity on that surface, but very unlike those marks of the permanent teeth by which we judge of the age. The number of teeth in the front of the mouth are 12, 6 in the lower, and 6 in the upper jaw. (We take no notice of the molares or grinders, as they are not concerned with this subject.) When a colt is three years old, we may observe that the four front sucking teeth are lost, and that, instead of them, four others have sprung up, of a very different appearance, being larger, of a darker colour, and having a considerable cavity on the upper surface, and a small dark coloured groove in front; these are termed *Horse's* or *permanent teeth.* Between the third and fourth year, the four teeth next these are lost, and replaced, in the way we have just described, by *horse's teeth*; so that when a colt has completed his fourth year, there are eight *horse's teeth* observable, and only four *colt's teeth*, one at each extremity, or corner, as it is termed: about the middle of the fifth year, these also fall out, and are succeeded by *horse's teeth.* The corner teeth of the horse, particularly of the under jaw, are different from the rest, being smaller and of a shell-like appearance, their cavities are chiefly within, the upper surface being a mere edge, but about the end of the fifth year they are larger, and more like the other teeth. It is generally between the fourth and fifth year that the tushes make their appearance, though sometimes earlier.—The tushes are four in number, and situated about an inch from the corner teeth; at first they are small, terminate in a sharp point, are rather convex on their external surface, but within have two concavities or grooves, separated by a ridge. These, as well as the teeth, are gradually undergoing an alteration in their form, becoming longer, and losing the concavities on the internal surface. About the seventh year the concavity is considerably diminished, and in old horses the surface becomes convex, the tush acquires a round form, and the extremity, instead of being sharp, is quite blunt, as if the point had been broken off, and the new surface afterwards polished. We must now return to the teeth, the appearances of which we have described, as far as the completion of the fifth year of a horse's age. After this period, we judge of the age by the size of those cavities which we have described on the upper surface of the tooth; for the friction to which that surface is almost constantly exposed, gradually wears it down, and at length the cavity or mark is totally obliterated. The marks in the upper teeth most commonly remain until the twelfth year, sometimes longer, but those in the under teeth are worn out about the end of the eighth year; we shall therefore confine our description now, to the under jaw.

As the two front teeth are the first that make their appearance, it is obvious that their marks will be lost sooner than those of the other teeth; and, if we examine the mouth of a horse that has just completed his fifth year, we shall find, that they are nearly, and sometimes quite worn out; those in the adjoining teeth are about half their original size, while the marks of the corner or end teeth are perfect. At the end of the sixth year, the only cavities observable, are in the corner teeth,

and these are about half their original size; the tooth has at this period lost its shell-like appearance which we have before described, and is not different from the other teeth, except in having a mark or cavity on its upper surface. At the end of the seventh year, the marks of the corner teeth also are obliterated, and then the horse is said to be aged. We often find, however, that the marks of the corner teeth are not totally effaced at this period, a small dark coloured spot may be observed in most horses, until about the end of the eighth year; from this period we have no criterion by which the age may be ascertained; but, it is said, that the marks of the upper teeth will enable us to judge of the age until the thirteenth year, the marks of the front teeth being worn out when he becomes eight years old, those of the adjoining teeth at ten, and the corner teeth at twelve; but I cannot say how far these marks can be depended upon.

FASCETS, in the art of making glass, are irons thrust into the mouths of bottles, in order to convey them to the annealing tower. See GLASS.

FAWN COLOUR. This colour is given to stuffs, by common sumach, which inclines to green, or by using other vegetable substances. Soot is also employed to communicate a fawn colour to wool, which is more or less deep, according to the quantity used. See DYEING.

FEATHERS, dyeing of. See DYEING.

FEATHERS. The feathers of birds make a considerable article of commerce, particularly those of the ostrich, heron, swan, peacock, goose, &c. for plumes, ornaments of the head, filling of beds, and writing pens.

There are scarcely any birds, but what bed-feathers may be procured from, particularly those of the domestic kind; yet swans, geese and ducks, are those that furnish most, and the best.

The feathers of dead birds are in the least esteem, upon account of the blood imbibed by the quill; which putrifying, communicates an offensive smell to the feather, and takes some time to evaporate; for which reason, live birds should not be stripped till their feathers are ripe.

The best feathers should be white, downy, void of large stems, fresh and sweet. Care should be taken, that no sand be intermixed, which is frequently practised to increase the weight.

Feathers must be freed from their animal oil, before they are fit to put into beds; otherwise they become infected with insects, or smell offensively.

The common process is to bake them; but in thus treating them, they are often singed: the following method does not seem liable to any objection, and promises to be a useful addition to our stock of economical knowledge.

Take for every gallon of clean water, one pound of quicklime; mix them well together, and when the undissolved lime is precipitated in fine powder, pour off the clear lime water for use at the time it is wanted.

Put the feathers to be cleaned, in another tub, and add to them a quantity of the clear lime water, sufficient to cover the feathers about three inches, when well immersed and stirred about therein. The feathers, when thoroughly moistened, will sink down, and should remain in the lime water three or four days; after which the foul liquor should be separated from the feathers by laying them on a sieve.

The feathers should be afterwards well washed in clean water, and dried upon nets: the meshes about the fineness of cabbage nets.

The feathers must from time to time be shaken upon the nets, and as they dry, will fall through the meshes, and are to be collected for use. The admission of air will be serviceable in the drying: the whole process will be completed in about three weeks. After being prepared as abovementioned, they will only require beating for use.

FELT, in commerce, is a sort of stuff deriving all its consistence from being fulled, or wrought with lees and size, without either spinning or weaving.

Felt is either made of wool alone, or of wool and hair.

FERMENTATION, VINOUS. Without troubling the reader with matter purely theoretical, we shall merely observe, that this process implies a change in saccharine fluids, by which the sugar is converted into spirituous or intoxicating liquor, capable of affording alcohol by distillation. The circumstances necessary to facilitate fermentation, are, besides the presence of saccharine matter and water, an increase of temperature. Thus an infusion of malt, which contains much sugar, by fermentation is converted into beer or malt liquor; the juice of the grape into wine; and the greater part of vegetable substances, when previously prepared, such as rye, corn, the refuse of sugar and several vegetable juices, as of the apple, by th same process, is changed into a spirituous liquor, or compound, which by distillation yields spirit, or alcohol. The phenomena of fermentation, being characterized by the disengagement of carbonic acid gas, in con-

sequence of a change among the elementary principles, is always apparent when the materials, of which the ferment consists, is in such proportion as to effect that change. In a word, it may be generally observed, that saccharine matter promotes the vinious fermentation, mucilage, the acetous; and gluten, the putrefactive: the first producing spirit, the second, vinegar, and the third, ammonia. See Brewing, Alcohol, Brandy, Wine, &c.

FERMENTED LIQUORS.—Fluids obtained or changed by the process of the vinous fermentation, by which the product is rendered intoxicating, are called fermented. We shall therefore refer to the articles, Beer, Brewing, Cyder, Wine, &c. for information on this subject.

FERNAMBOUC WOOD.—See Brazil Wood. Dyeing.

FERRETS, among glass-makers, the iron with which the workmen try the melted metal.

FERRETTE, in glass making, a substance which serves to colour glass. See Glass.

FEURSTEIN.—See Flint.

FILES *of stoneware*, invented by G. Cumberland Esq. who in a letter to Mr. Nicholson on the subject of making files from clay, says—

That to have applied so soft a substance as clay to the purpose of lograting the hardest bodies, would have appeared to some as impossible; neither should he perhaps have ever thought of such an application in the form he now uses it, had he not found, in shaping some substances, that the wear of his steel files was rather expensive.

It then first occurred to him, in ranging in thought after a remedy, that, as stoneware is so hard as to blunt files, files might be as well made of our stoneware. This was about two years ago, and the first use he made of the suggestion was, to fold up in muslin, cambrick, and Irish linen, separate pieces of wet clay, forcing them by the pressure of the hand into the interstices of the threads, so as on divesting them of the covering to receive a correct mould. These he had well baked, and immediately found he had procured an intire new species of file, capable even of destroying steel; and very useful indeed in cutting glass, polishing, and rasping wood, ivory, and all sorts of metals.

The ease with which he had accomplished his purpose, as is too often the case, made him content himself with the use of his own discovery, or at most giving away a few specimens as files for ladies nails of peculiar delicacy; but having since reflected, that in glass grinding (the stones for which come from the North, and are very expensive) in flatting metallic mirrors, laying mezzotinto grounds, and a number of operations that require an expensive friction, these stoneware graters, if we may so call them, as not being of the exact shape of files, may ultimately become very useful. He says that he takes a pleasure in furnishing a description of his method in applying this substance, accompanied with a specimen or two of a portable size, that we may the better be able to judge of their value to the arts, as in all operations of grinding a great deal of manual labour must first be bestowed on the too whereas here we may mould in an instant, if we use a press, as in pipe making, and the expense is infinitely inferior to that incurred in constructing even the cheapest file or lograter.

Mr. Nicholson observes, that this ingenious invention promises to be of considerable use in the arts. The abrasion of surfaces is performed either by a toothed tool, as in filing, rasping. &c.; or by a grinder, in which cutting or hard particles are bedded with considerable firmness in a softer mass; or by scowering, polishing, &c, in which hard particles are more or less slightly retained in a soft or tenacious substance. Mr. Cumberland's instruments appear to promise great utility in the first and last of these processes; that is, they may be used either with or without a fretting powder. There are however many objections to their being used to grind speculums; not only with regard to the intended figure, but the nature of the material.

FILTRATION. This is a process of straining or filtering liquors by means of woolen cloth, cotton, linen, paper, or other material. All substances which are suspended, or mechanically mixed with a fluid, by which it is rendered turbid or thick, are separated by this process; but the substances, which are actually dissolved or held in solution, or otherwise chemically combined with a fluid, can not be separated by this means.

An apparatus fitted up for this purpose is called a filter. The form of this is various, according to the intention of the operator. A piece of tow, or wool, or cotton, stuffed into the pipe of a funnel, will prevent the passage of grosser particles, and by that means render the fluid clearer which comes through. Spunge is still more effectual. A strip of linen rag wetted and hung over the side of a

vessel containing a fluid, in such a manner as that one end of the rag may be immersed in the fluid, and the other end may remain without, below the surface, will act as a syphon, and carry over the clearer portion. Linen or woollen stuffs may either be fastened over the mouths of proper vessels, or fixed to a frame, like a sieve, for the purpose of filtering. All these are more commonly used by cooks and apothecaries than by philosophical chemists, who, for the most part, use the paper called bloom paper, made up without size.

As the filtration of considerable quantities of fluid could not be effected at once without breaking the filter of paper, it is found requisite to use a linen cloth, upon which the paper is applied and supported.

Precipitates and other pulverulent matters are collected more speedily by filtration than by subsidence. But there are many chemists, who disclaim the use of this method, and avail themselves of the latter only, which is certainly more accurate, and liable to no objection where the powders are such as will admit of edulcoration and drying in the open air.

Some fluids, as turbid water, may be purified by filtering through sand. A large earthen funnel, or stone bottle with the bottom beaten out, may have its neck loosely stopped with small stones, over which smaller may be placed, supporting layers of gravel increasing in fineness, and lastly covered to the depth of a few inches with fine sand, all thoroughly cleansed by washing. This apparatus is superior to a filtering stone, as it will cleanse water in large quantities, and may readily be renewed when the passage is obstructed by taking out and washing the upper stratum of sand.

A filter for corrosive liquors may be constructed on the same principles of broken and pounded glass.

A patent has been lately granted to Mr. James Peacock, for a filtering machine, which consists in causing the turbid fluid to ascend through a medium of fine gravel, of progressive degrees of fineness. The machine, it is said, does not occupy more room than a large drip stone, and yields a constant and pure stream of more than 300 gallons in 24 hours.

There does not require any arguments to prove the beneficial effects of pure soft water to the preservation of health; a useful and convenient apparatus is the chief object by which it is to be obtained. The proper materials of which vessels designed to contain water should be made, are glass, porcelain, or stone-ware, and ashen wood, such as is used in dairies, &c. for large reservoirs, brick, marble, stone, in tarras, or barren lime may be the best. A wooden cistern lined with lead, or a strong leaden one itself, may be sufficient, when the expense or inconvenience may render the others objectionable. The substance and dimensions of the cistern being determined. it should be divided into three compartments: the first division to receive the turbid water from the service-pipe; the second to contain Mr. *Peacock's* stratified medium for the filtration: and the third to receive the water in its clarified state, after its ascent through the filter.

Gravel of different sizes, suitable to the several strata, are necessary to produce the filtration. Mr. *Peacock* also thinks that glass reduced to the sizes is the most proper; but should any other preferable materials be suggested, the inventor would be ready to adopt them.

Different sizes of gravel appear to us easily to be obtained, by sifting it in different sized wire sieves. Mr. *Peacock* in his work does not describe this. The various sizes of the particles of gravel, as placed in layers, should be nearly in the quadruple ratio of their surfaces; that is, upon the first layer or stratum a second is to be placed, the diameters o whose particles are not to be less than one half of the first, and so on in this proportion; and as this theory supposes the particles to be spheres, in practice it is necessary to increase the height or thickness in each stratum, as may be necessary, to correct the irregularities in their form: experience only will best determine this. This arrangement of filtering particles will gradually refine the water by the grosser particles being quite intercepted in their partly ascending with the water. The operation will be more clearly understood by the following description of the glass vessels in which Mr. *Peacock* first made his experiment.

Plate [Peacocks Filtering Apparatus] fig. 1. represents the plan and action of these cylindrical glass vessels. A is the one to receive the turbid water, served from any cistern or other means by the pipe and ball-cock at D. E is a straining-cloth, to clear the water from filaments, &c. it is in the form of a bag, which may, by being fixed to a hoop, be kept on the top of the vessel. The cock may be turned, and the ball taken off occasionally. The glasses are contained in a light frame lined at bottom and about three inches up the sides with sheet lead, to form a recipient for the waste water from the cocks in the glasses. The tur-

Peacock's filtering Apparatus.

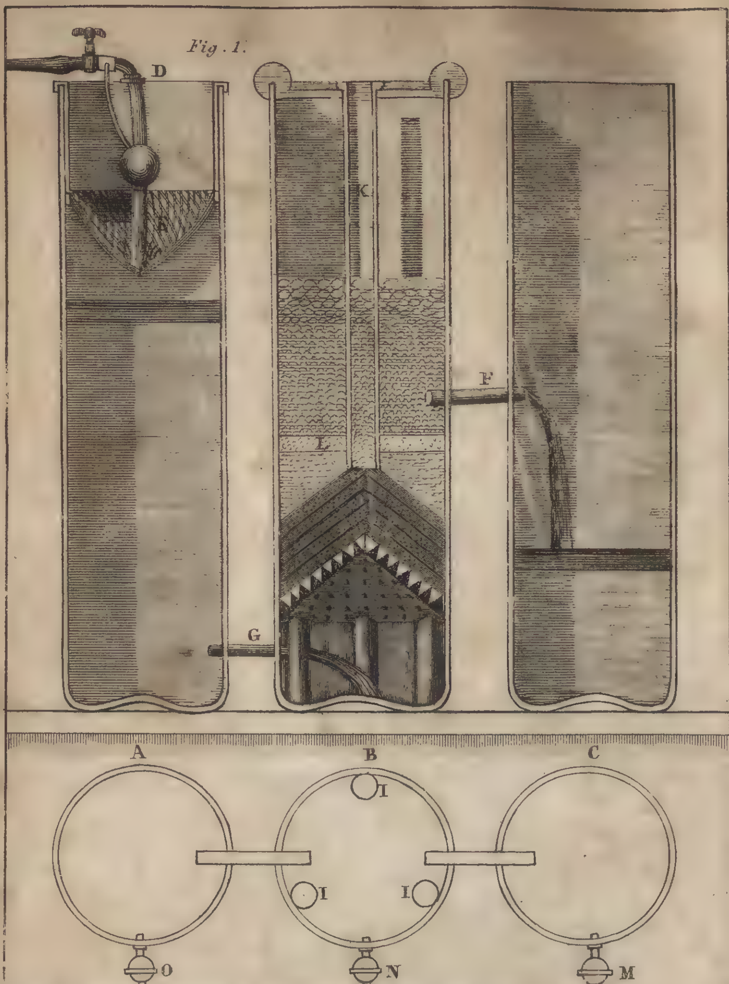
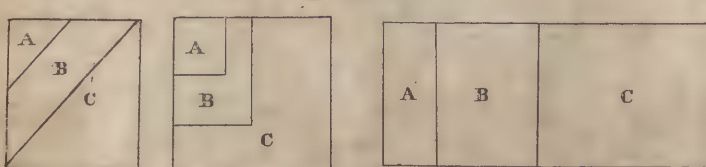


Fig. 2.



H. Anderson sc.

bid water from the vessel A, passes by the pipe G, into the lower part of the vessel B, under a spherical or conical form of grating H, which is supported by three feet I, I, I. Upon this grating are laid the several strata of gravel, or the filtering medium to the height proper to receive the lower end of the air-pipe K, which pipe is supported at the top of the glass. Afterwards the remainder of the strata is placed round the pipe, in proper order, till a secure foundation is obtained for the finest stratum, which is the main agent in the percolation, and is represented at L. Upon this the others are laid, but in an inverse order, and to such a height, that the whole medium shall resist any disturbance from the pressure of the column of the water in A. The air-pipe, K, is charged to a similar height, beginning with a degree coarser than that at the bottom of the pipe, leaving out the finest stratum; whence, as the water passes from the vessel A, through G, into the cavity below H, in the vessel B, the air from the cavity, and from the interstices of those strata which lie below the end of the pipe K, is driven up the said pipe, and permits the water to rise to the pipe F, in a filtered state, and through which it passes into the vessel C, from which it is drawn by the cock M A portable apparatus of this kind will serve for a family of six or eight persons.

When the operation appears uncommonly languid, it will be proper to let all the vessels be as full as possible, which will be in the course of a night in its worst state, and the next morning a stop-cock, in the pipe G, may be turned, and the cock, N, opened to discharge all the water in the vessel B, together with as much of that in C, as shall be above the pipe F. By this means, the reflux of the water carries down with it all the feculences and obstructions, and the degree of filtration is restored, as at first. Mr. *Peacock* says, that this cleansing is not required oftener than five or six times in a year, unless the original water comes in uncommonly turbid. This cleansing may also, at any time, in a few minutes be effected, by shutting the cock at D, and opening the cock at O. All the water of the third vessel above the pipe F, together with the whole of the second vessel, down to the pipe G, would flow back, and pass through the cock O.

Fig. 2, will convey Mr. *Peacock's* idea of plans of three vessels, made of earth, stone, marble, &c. wherein the space, A, represents the bottomless tube, which is to receive the turbid water from the pipe, and discharge the air from the grating, &c. under it. B, the part in which the filtering medium is to be placed, and C, the part to receive the cleared water. The vessels of these square forms will require to be well joined or clamped together, as circular forms are not essential. Ingenious workmen can avail themselves of this hint.

For other ingenious contrivances of vessels for sea, camp, or garrison service, as well as a plan for building a filter to supply a village or district, we must refer the reader to Mr. *Peacock's* own publication.

A filtering apparatus for the use of large ships, was lately invented by Dr. Edward Cutbush, and found to answer remarkably well. A view of the machine may be seen in Cutbush's Observations on the Means of Preserving the Health of Soldiers and Sailors. Several contrivances were invented for the same purpose. Professor Parrot of Paris has made a machine, and given some observations on its use, which may be seen in the Domestic Encyclopædia A machine was invented in Paris by Mr. Smelt, which purified water by passing it through sponge, and then through alternate layers of chalk, sand, and charcoal It is said that the efficacy of this machine was such, that water taken out of the gutter, was drank perfectly pure in 20 minutes.

In addition to what we have said on this subject, the following method of applying the filtering stone for purifying water, by Mr. William Moult, may be interesting. Mr M. observes, that his objections to the old method of filtering by putting water into the filtering stone are, that the dirt falls to the bottom, and fills up, or chokes the pores of the filtering-stone, so that the stone requires frequently to be cleaned with a brush and sponge to allow the water to pass, after which the water passes through the stone in a muddy state for two or three days; it likewise requires to be frequently filled, and as it empties, less water comes into contact with the stone, and therefore a smaller quantity, in such a state, can only pass through. Likewise a filtering stone used in the common way soon becomes useless, from the filth insinuating itself into the internal parts of the stone, out of the reach of the brush.

In his method, the filtering-stone is placed within the water to be purified, which presses upon the outside of the filter, and the stone does not require to be supported in a frame, as it needs only to stand within the water cistern; it will thus filter, in an equal time, double the quantity of water procured in the com-

mon mode; it fills itself, and requires no cleaning.

The accompanying certificates will shew the importance of this improvement.

We, the undersigned, having inspected and examined a new mode of employing the ordinary filtering-stone, discovered by William Moult, are of opinion that its superiority over the customary method is so great as to entitle it to particular notice.

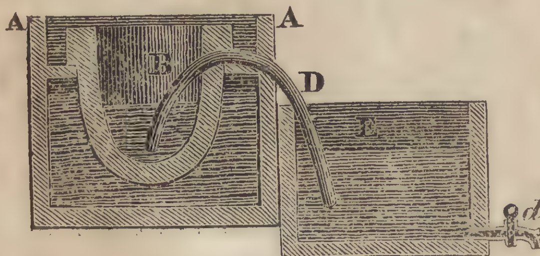
That it not only supplies an infinitely greater quantity of purified and limpid water, but is capable of preserving its porosity free and pervious for years together, by an occasional self-operation.

That by this valuable process the principal objections to drip-stones is removed, viz. the constant labour they require to keep them clean by means of brushes, without eventually producing the intended effect, and without preventing their being finally rendered useless.

D'Arcy Preston, captain in the royal navy; Charles Gower, M. D.; Thomas Pitt, Esq. V. P. Wimpole street; Richard Davenport, Esq. Wimpole street.

Reference to the drawing of Mr. Moults filtering apparatus, Fig. 1, Plate 2.

AA is the cistern containing the water to be filtered; the filtering stone B is suspended in the cistern by a ring around the inside of it, which catches the projecting part of the stone; the water in the cistern filters through into the stone. D is a siphon, which conveys the filtered water from the inside of the stone into a cistern E, which is the reservoir for clean water. *d* a cock to draw it off as it is wanted. By this mode of filtration the impurities of the water are deposited in the bottom of the cistern A, instead of being left in the bottom of the stone as in the usual mode.



FINE-STILLER, in the distillery, the person who performs that branch of distilling which relates to the preparation of spirit from treacle or the refuse of sugar, in contradistinction to the *malt-stiller*. See DISTILLING.

FIRE DAMP, in mining, is that inflammable gas generated in many mines, particularly coal pits, which often produces most dreadful explosions. It is only to be prevented by thorough ventilation.

FIRE-PLACES. Count Rumfords improvement of. Without going into the merits of Count Rumfords improvements in the construction of fire places, as they are sufficiently established, we shall only subjoin a few cuts, with some remarks, which we have extracted from his useful work.

The following are sketches of the Counts improved chimney fire places.

It will be found that the best form for the vertical sides of a fire-place, or the covings as they are called, is that of an upright plane, making an angle with the plane of the back of the fire-place of about 135 degrees. According to the present construction of chimnies, this angle is ninety degrees, or forms a right angle; but as, in this case, the two sides or covings of the fire-place, A C, B D, fig. 1, are parallel to each other, it is evident that they are very ill contrived for throwing into the room, by reflection, the rays from the fire which fall on them.

To have a perfect idea of the alterations, the Count proposes in the fire places, the reader need only observe, that the backs of fire-places as they are now commonly constructed, are as wide as the opening of the fire-place in front, the sides being perpendicular to it, and parallel to each other. In the fire-places he recommends, the back, *i k*, fig. 1, is only about one-third of the width of the opening of the fire-place in front, *a b*, and, consequently, the two

sides or covings of the fire-place, *a i* and *b k*, instead of being perpendicular to the back, are inclined to it in an angle of about 135 degrees; and in consequence of this position, instead of being parallel to each other, each of them presents an oblique front towards the opening of the chimney, by means of which the rays which they reflect are thrown into the room. A bare inspection of the sketches, fig. 1 and 2, will render this matter very intelligible.

Fig. .1

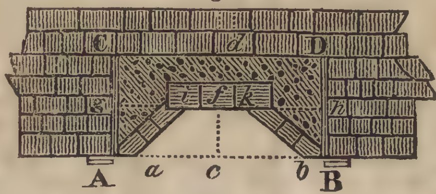


Fig. 2.

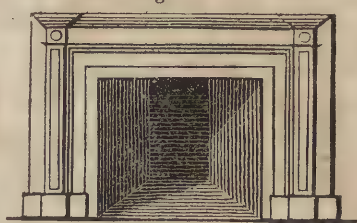


Fig. 3.

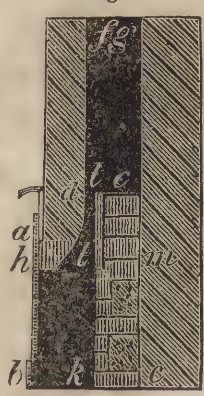


Fig. 4.

It will be proper to begin by explaining the precise meaning of all those technical words and expressions which we find it necessary to use.

By the throat of a chimney, we mean the lower extremity of its canal, where it unites with the upper part of its open fire-place. This is commonly formed about a foot above the level of the lower part of the mantle; and it is sometimes contracted to a smaller size than the rest of the canal of the chimney.

Fig. 3. shews the section of a chimney on the common construction, in which *d e* is the throat.

Fig. 4. shews the section of the same chimney altered and improved, in which *d l* is the reduced throat.

The breast of a chimney is that part of it which is behind the mantle. It is the wall which forms the entrance from below into the throat of the chimney in front, or towards the room; it is opposite to the upper extremity of the back of the open fire-place, and parallel to it; in short, it may be said to be the back part of the

mantle itself. In fig. 3 it is marked by the letter *e* and by *d* in fig. 4. The width of the throat of the chimney, *d e*, fig. 3, and *d l*, fig. 4, is taken from the breast of the chimney to the back, and its length is taken at right angles to its width, or in a line parallel to the mantle, *a*, fig. 3 and 4.

Directions for laying out the work.—If there be a grate in the chimney, which is to be altered, it will always be best to take it away; and, when this is done, the rubbish may be removed, and the hearth swept perfectly clean.

Suppose the annexed figure, fig. 1, to represent the ground-plan of such a fire-place; A B being the opening of it in front A C and B D the two sides or covings, and C D the back.

Fig. 3. shews the elevation of this fire-place.

First draw a straight line with chalk, or with a lead pencil, upon the hearth from one jamb to the other, even with the front of the jambs. The dotted line, *a*, *b*, fig. 1, may represent this line.

From the middle, *c*, of this line, *a b*, another line *c d*, is to be drawn perpendicular to it, across the hearth, to the middle, *d*, of the back of the chimney.

A person must now stand upright in the chimney, with his back to the back of the chimney, and hold a plumb-line to the middle of the upper part of the breast of the chimney, *e*, fig. 3, or where the canal of the chimney begins to rise perpendicularly; taking care to place the line above in such a manner, that the plumb may fall on the line, *c d*, fig. 1, drawn on the hearth from the middle of the opening of the chimney in front to the middle of the back, and an assistant must mark the precise place *e*, on that line where the plumb falls.

This being done, and the person in the chimney having quitted his station; four inches are to be set off on the line *c d* fig. 1, from *e*, towards *d*; and the point *f* where these four inches end (which must be marked with chalk, or with a pencil) will shew how far the new back is to be brought forward.

Through *f*, draw the line *g h*, parallel to the line *a b*, and this line, *g h*, will shew the direction of the new back, or the ground-line upon which it is to be built.

The line *c f*, will shew the depth of the new fire-place; and if it should happen that *c f* is equal to about one-third of the line *a b*; and if the grate can be accommodated to the fire-place, instead of its being necessary to accommodate the fire-place to the grate; in that case half the length of the line *c f*, is to be set off from *f* on the line *g f h*, on the one side to *k*, and on the other to *i*, and then the line, *i k*, will shew the ground-line of the fore-part of the back of the chimney.

In all cases where the width of the opening of the fire-place in front, A B, happens to be not greater, or not more than two or three inches greater, than three times the width of the new back of the chimney *i k*, this opening may be left, and lines drawn from *i* to A, and from *k* to B, will shew the width and position of the front of the new covings: but when the opening of the fire-place in front is still wider, it must be reduced; which is to be done in the following manner:

From *c*, the middle of the line *a b*, *c d* and *c b* must be set off equal to the width of the back *i k*, added to half its width *f i*, and then lines drawn from *i* to *a*, and from *k* to *b*, will shew the ground-plan of the fronts of the new covings.

When this is done, nothing more will be necessary than to build up the back and covings; and, if the fire-place be designed for burning coals, to fix the grate in its proper place, according to the directions already given. When the width of the fire-place is reduced, the edges of the covings *a* A and *b* B are to make a finish with the front of the jambs. And in general it will be best, not only for the sake of the appearance of the chimney, but for other reasons also, to lower the height of the opening of the fire, whenever its width in front is diminished.

Fig. 2, shews a front view of the chimney after it has been altered according to the directions here given.

By comparing it with A B C D, fig. 1, which shews a section of the same chimney before it was altered, the manner in which the opening of the fire-places in front is diminished may be seen. In fig. 2, the under part of the door-way, by which the chimney-sweeper gets up the chimney, is represented by white dotted lines. The door-way is represented as closed.

FIRING-IRON *in Farriery*, an instrument used for cauterising and discussing preternatural swellings See FARRIERY.

FISH SOAP, is a kind of soap lately attempted to be introduced in manufactures, made by dissolving refuse fish of all kinds in caustic alkali. See SOAP.

FISH-OIL, Purification of, according to Dorsie.

Process the First—For purifying fish-oil, in a moderate degree, and at a very little expence.

Take an ounce of chalk in powder, and half an ounce of lime, slacked by exposure to the air; put them into a gallon of stinking oil, and having mixed them well toge-

ther by stirring, add half a pint of water, and mix that also with them, by the same means. When they have stood an hour or two, repeat the stirring, and continue the same treatment at different intervals, for two or three days; after which superadd a pint and a half of water, in which an ounce of salt had been dissolved, and mix them as the other ingredients, repeating the stirring as before for a day or two. Let the whole stand at rest, and the waer will sink below the oil, and the chalk subside in it to the bottom of the vessel. The oil will become clear, be of a lighter colour, and have considerably less smell, but will not be purified in a manner equal to what is effected by the other processes below given; though as this is done at the expense of only one ounce of salt, it may be practised advantageously for many purposes, especially as a preparation for the next method, the operation will be thereby facilitated.

Process the second.—To purify, to a great degree, fish-oil without heat.

Take a gallon of crude stinking oil, or rather such as has been prepared as abovementioned, and add to it an ounce of powdered chalk; stir them well together several times, as in the preceding process; and after they have been mixed some hours or a whole day, add an ounce of pearl ashes, dissolved in four ounces of water, and repeat the stirring as before. After they have been so treated for some hours, put in a pint of water in which two ounces of salt are dissolved, and proceed as before: the oil and brine will separate on standing some days, and the oil will be greatly improved both in smell and colour. Where a greater purity is required, the quantity of pearl ashes must be increased, and the time before the addition of the salt and water prolonged.

If the same proportion is repeated several times, diminishing each time the quantity of ingredients one half, the oil may be brought to a very light colour, and rendered equally sweet in smell with the common spermaceti oil. By this process the cod-oil may be made to burn; and when it is so putrid as not to be fit for any use, either alone or mixed, it may be so corrected by the first part of the process, as to be equal to that commonly sold: but where this process is practised in the case of such putrid oil, use half an ounce of lime.

Process the third.—To purify fish oil with the assistance of heat, where the greatest purity is required, and particularly for the woollen manufacture.

Take a gallon of crude stinking oil, and mix it with a quarter of an ounce of powdered chalk, a quarter of an ounce of lime, slacked in the air, and half a pint of water; stir them together; and when they have stood some hours, add a pint of water and two ounces of pearl-ashes, and place them over a fire that will just keep them simmering, till the oil appears of a light amber colour, and has lost all smell except a hot greasy, soap-like scent. Then superadd half a pint of water, in which an ounce of salt has been dissolved; and having boiled them half an hour, pour them into a proper vessel, and let them stand till the separation of the oil, water and lime be made, as in the preceding process. When this operation is performed to prepare oil for the woollen manufacture the salt may be omitted; but the separation of the lime from the oil will be slower, and a longer boiling will be necessary.

If the oil be required to be yet more pure, treat it, after it is separated from the water, &c. according to the second process with an ounce of chalk, a quarter of an ounce of pearl ashes and half an ounce of chalk.

In his observations on these different processes the author apprises us, that process the first will render oils more fit for burning, which are in that point faulty, and is of use merely when a moderate improvement is required. That when the oil is taken from the dregs and brine, the dregs should likewise be taken off and put into another vessel of a deep form, fresh water added, and stirred with them, and nearly the whole of the remaining part of the oil will separate from the foulness; or the dregs may be put to any future quantity of oil that is to be edulcorated by this method, which will answer the same purpose.

Process the third he says is best for train oil, called vicid whale oil; and the more putrid and foul, the greater the proportional improvement, especially if there be no mixture of the other kinds of fish-oils, particularly the seal, which do not admit of being edulcorated by heat. Oil thus purified will burn without leaving any remains of foulness, and being more fluid than before, will go further when used in woollen manufacture, and be more easily severed from the wool.

If a more thick oil be wanted, a certain proportion of tallow or fat may be added, and kitchen stuff, which will dissolve in oil moderately heated. It may be necessary to vary the proportions of the ingredients, if the oil be very vicid, as the quantity above stated is the least that will be suitable. If in six or eight hours simmering the oil does not appear to be im-

proving, a fourth or third part of the original quantity may be added. Fresh additions of water must be made as the quantity is lessened by evaporation. If it be inconvenient to give the whole time of boiling at once, the fire may go out and be rekindled at any distance of time, and a small proportion of pearl ashes dissolved in water being added and stirred in between the time of boiling will facilitate the operation.

Process the fourth.—Which may be practised instead of process the first, as it will purify fish-oil to a considerable degree, and for process the third when the whole is performed.

Take a gallon of crude fetid oil, and put it to a pint of water, poured from two ounces of lime slacked in the air; let them stand together, and stir them several times for the first twenty-four hours; then let them stand a day, and the lime water will sink below the oil, which must be carefully separated from them. This oil, if not sufficiently purified, to be treated as in process the third, diminish the quantity of pearl ashes to one ounce and omit the lime and chalk.

The dregs remaining after the sundry processes above mentioned, will form an excellent manure, as has been since noticed in Dr. Hunter's Georgical Essays.

FISH GLUE.—See Gelatine.

FIXED AIR.—This air, called fixed by Dr. Black, and carbonic acid gas by modern chemists, is a compound of carbon, oxygen, and caloric. Carbonic acid gas exists in limestone, marble, chalk, stalactite, &c. from which it is disengaged by the addition of acids, as the sulphuric, nitric, &c. As it is found in cellars, wells, &c and as it is deleterious to animal life, its presence may be known by letting down a lighted taper; which, if extinguished, indicates this gas. It may be removed by throwing quicklime into the well or cellar, as this has the property of absorbing it, or otherwise rendering it fixed in the substance of the lime.

FLAKES are certain pigments used in painting, such as *flake white*, &c. See Colour-Making.

FLANEL, or FLANNEL, a kind of light, loose, woollen stuff, composed of a woof and warp, and wove in a loom with two treddles, after the manner of lays. See Weaving.

FLAX. See Agriculture.

FLINT. *Fuerstein.* Wern.

The colour of this mineral is smoak-grey, of different shades, passing into greyish-black, and almost perfect black, or yellowish-grey, passing into yellowish-white, wine and ochre yellow; it also occurs blueish-grey, yellowish and reddish-brown. Two or more colours, are often found in the same specimen, forming points, spots, clouds, or stripes. It generally also exhibits opake white spots. It occurs in mass, disseminated, in angular grains and fragments, in globular and tubercular masses, or carious, and amorphous, sometimes also in pseudo-crystals, eitherpyramidal or prismatic moulded on calcareous spar. It also constitutes the substance of various petrifactions as echinites, earths and coralloids. Its external lustre is casual, internally it is glimmering. Its fracture is perfectly conchoidal: it breaks into indeterminately angular and very sharp-edged fragments. It sometimes, though rarely, occurs in lamellar distinct concretions. It is translucent, varying in degree, according to the depth of colour, the very light-grey varieties being semi-transparent. Its hardness is a little greater than that of quartz, it is easily frangible in any direction. Sp. gr. 2.58 to 2.59.

When exposed to the blow-pipe it becomes of an opake-white, but is wholly infusible without addition. By being heated red hot in a distillatory apparatus, it yields from one to two per cent. of a somewhat empyreumatic water, and a little carbonic acid. If projected on fused nitre, it gives out a few sparks, accompanied by a slight detonation. It has been analysed by Klaproth and Vauquelin, with the following results.

	Klap.	Vauq.
Silex	98.	97.
Lime	0.5	0.
Alumine	0.25	1.
Oxyd of Iron	0.28	
Loss	1.	2.
	100	100

The cloudy and opake greyish specks which frequently occur in this mineral, contain, according to Vauquelin, from two to five per cent. of carbonated lime, and the white opake crust with which those specimens are covered that are taken immediately out of chalk, consists, according to the same able chemist of

Silex	86.42
Oxyd of iron	1.23
Carbonated Lime	9.88
Loss	2.47
	100

Flint occurs sometimes, though rarely, in primitive rocks forming veins, but when belonging to this formation its fracture has a tendency to splintery, and is less easily frangible than common flint, and in fact,

appears to be a variety of hornstone passing into chalcedony. Common flint occurs in rounded pebbles, constituting the greater part of the extensive beds of gravel, which accompany the ranges of chalk hills, but here it is evidently worn by attrition and disposed in a fortuitous irregular manner. It is only in the chalk hills themselves, that it appears in its na tive repository: here it is disposed in regular beds alternating with the chalk; and detached masses are often enveloped in the chalk itself. A bed of flint is never a continuous stratum, but is composed of irregular flattened nodules, with tubercular or long projecting processes, each separated from the other by ochery chalk —yet the whole bed preserves its parallelism very exactly. Many nodules are hollow, and if the cavity communicates with the outide, are, for the most part, filled with chalk; but, if there is no external aperture, the hollow is lined with minute pyramids of quartz, or tubercles of chalcedony.

These flints, which burn to a pure white colour, are employed in the finer kinds of pottery. The light coloured flints are made into gun-flints, for which they are admirably qualified by the vivacity of sparks, which they yield on collision with steel, and from the ease with which they are manufactured. Flints occur in abundance in the United States. Dolomieu has given an excellent treatise on the art of making gun-flints, which we have abridged.

Instruments.

The instruments used for fashioning the gun-flints, are four in number:

1. A small piece of iron or mace, with a square head, the weight of which does not exceed two pounds, or, perhaps a pound and a half, with a handle, seven or eight inches long. This instrument is not made of steel, because if it were too hard, its stroke might shatter the flint, instead of breaking it by a clear fracture.

2. A hammer with two points, in which the position of the points is of consequence as to the nature of the stroke This hammer must be of good steel well hardened, and does not weigh more than sixteen ounces; some do not exceed ten It is fixed on a handle seven inches long, which passes through it in such a manner, that the points of the hammer are nearer the hand of the workman, than the centre of gravity of the mass. The form and size of the hammers of different workmen vary a little, but this disposition of the points is common to them all, and is of consequence to the force and certainty of the blow.

3. A little instrument named Roulette (roller) which represents a solid wheel, or segment of a cylinder, two inches and one third in diameter. Its weight does not exceed twelve ounces; it is made of steel, pot hardened, and is fixed on a small handle six inches long, which passes through a square hole in its centre.

4. A chissel bevelled on both sides, seven or eight inches long, and two inches wide, of steel not hardened; it is set on the block of wood which serves as a work bench, out of which it rises to the height of four or five inches. To these four instruments we may add a file, for the purpose of restoring the edge of the chissel from time to time.

The process:

After selecting a good mass of silex, the whole operation may be divided into four manipulations.

1. To break the block. The workman being seated on the ground, places the flint on his left thigh, and strikes it gently with the larger hammer, to divide it into portions according to its size, that is to say, of about a pound and a half each, with broad surfaces nearly flat. He is careful not to crack or produce shakes in the flint by striking it too hard.

2. To cleave the flint, or break it into scales. The principal operation of this art is to cleave the flint well: that is to say, to separate from it pieces of the length, thickness, and figure, adapted, to be afterwards fashioned into gun-flints; and in this part the greatest degree of address, and certainty of manipulation are required The stone has no particular direction in which it can be most easily broken. The course of its fracture depends entirely upon the choice of the workman. In this process he holds a piece of flint in his left hand, not supported, and strikes with the hammer, on the broad faces produced by the first fracture, in such a manner as to chip off the white coating of the stone in small scales, and to lay bare the silex in the manner represented, fig. 1.: after which he continues to strike off other similar portions of the pure silex. These pieces are nearly an inch and a half wide, two inches and a half long, and one sixth of an inch thick in the middle.

Fig. 1.

Fig. 2.

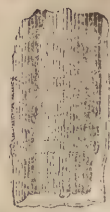


Fig. 3.

They are slightly convex within, and consequently leave a space somewhat concave, terminating longitudinally in two lines, somewhat projecting, and nearly strait. The prominent edges produced by the fracture of the first scales, must afterwards constitute nearly the middle of the subsequent pieces; and those pieces only, in which they are found, can be used to form gun-flints.

In this manner the operator continues to cleave, or scale the stone in different directions, until the natural defects of the mass render it impossible to make the fractures required, or until the piece is reduced too much to receive the small blows which separate the pieces.

3. *To fashion the flint.*

The gun-flint, fig. 3. may be distinguished into five parts; namely, 1. The edge, or bevel part, which strikes the hammer or steel. This is two or three twelfths of an inch in width. If it were broader it would be too liable to break; and if more obtuse, it would not afford a brisk fire. 2dly. The side edges, which are always somewhat irregular. 3dly. The back edge, most remote from the hammer where the stone possesses its intire thickness. 4thly. The under surface, which is smooth and slightly convex. And 5thly. The upper face, which is slightly concave, and receives the action of the upper claw of the cock, in which it is fixed for service.

In order to fashion the stone, those scales or chips are selected, which have at least, one longitudinal prominent angle. One of the two edges is fixed on to form the striking edge; after which, the two sides of the stone which are to form the side edges, and that which is to form the hinder edge, are successively placed with the convex surface upon the edge of the chissel, which is supported with the fore-finger of the left hand, at the same time that a small blow or two is given above the point of support with the Roulette, by which the stone breaks exactly along the edge of the chissel, as if it had been cut. In this manner the sides and posterior edge of the stones are made.

4. The stone being thus reduced to its proper figure, the finishing operation consists in completing its edge in a straight line. For this purpose, the stone is turned, and the under flat part of the edge is placed on the chissel, in which situation it is completed by five or six small strokes with the Roulette.

The whole operation of fashioning a gun-flint, is performed in less than one minute.

A good workman can prepare a thousand good chips or scales in a day, if his flints be of good quality, and he can also fashion five hundred gun-flints in a day; consequently, in three days, he will cleave and finish a thousand gun-flints without further assistance.

This manufacture leaves a great quantity of refuse; that is to say, about three-fourths of the whole stone. For there are not more than half the scales which prove to be well figured, and nearly half the mass in the best flints is incapable of being chipped out: so that it seldom happens that the largest piece will afford more than fifty gun-flints. The larger pieces of refuse are sold for the culinary purpose of striking a light.

The gun-flints when completed are sorted out, and sold at different prices, according to their degrees of perfection, from 4 to 6 decimes (or pence) the hundred. They are classed into fine flints and common flints; and, according to their application, into flints for pistols, fowling pieces, and muskets.

FLOORS earthen. Earthen floors are commonly made of loam, and sometimes, especially to make malt on, of lime, brook-sand, and anvil dust from the forge. Ox blood, and fine clay mixed together, it is said will produce a good floor. If two thirds of lime, and one of coal ashes well sifted, with a small quantity of loam, be mixed and tempered with water, and laid on the ground with a trowel 2½ or 3 inches thick, an excellent earthen floor will be formed. For elegance, coloured plaister is recommended.

FLOUR, the powder of wheat, rye, corn, &c. As grain contains, besides fecula, or starch, a quantity of gluten and saccharine matter, which may be severally separated by agitating it in cold water, it is obvious, that the use of warm water, yeast, &c, in the making of bread, consists in decomposing it, and changing its substance into an article, known by the name of bread. We have noticed the different processes necessary for this purpose. See Starch, Spirit, Fermentation, &c.

FLUMMERY, an article of food, prepared by boiling oatmeal in water; to which, after boiling, sugar and orange flower water are added.

FLUOR SPAR, called also Derbyshire spar, and fluate of lime. This spar, which is composed of fluoric acid and lime, is employed in obtaining fluoric acid for etching on glass (which see); as a flux for the reduction of various metallic ores; and, when massive and of a sufficient size, solidity, and beauty, for ornamental objects, suchas vases, basons, obelisks, &c.

This manufacture is entirely confined to Derbyshire, no other part of the world affording fluor sufficiently compact for this purpose. The fluor that is manufactured, commonly called *Derbyshire spar*, is found only in one mine a little to the west of Castleton; it there occurs in veins and detached masses from three inches to a foot in thickness. The method of manufacturing it is as follows.

When the fluor is intended to be worked into a vase or the like article, a piece is selected fit for the purpose, and if, after minute examination it be found free from defects, it is carved with a mallet and chissel into a spherical form, and then fixed on a chock with an exceedingly strong cement. The chock is then screwed on the lathe, a slow motion is produced and water continually drops on the stone to keep the tool cold, which is at first applied with great care. This tool is a piece of the best steel, about two feet long and half an inch square; it is reduced to a point at each end, and tempered to suit the work. As the surface becomes smoother the tool is applied more boldly and the motion much quickened, till the piece of fluor be reduced to its intended form.

The piece being thus formed and rendered smooth by the steel instruments, in order to render it fit to receive a polish, a coarse stone is applied with water so long as the smoothness is improved by these means; then finer grit-stone, pumice, &c. till the piece be sufficiently smooth to receive coarse emery, and afterwards fine emery. If with the latter it appear of a good shining gloss, then the finest putty is employed for a considerable length of time, till the polish be as bright as possible, which is known by throwing water on it. If the part thus watered appear higher polished than the rest, the polishing is continued till water will not heighten the appearance.

The advantages of a lathe worked by water is particularly conspicuous in forming delicate hollow vases, &c. for by the use of the foot-lathe the fluor was frequently broken, and its laminated texture at all times disturbed, but the use of the water-lathe by its steadiness prevents these inconveniences.

FLY-STONE, an arsenical iron ore, which, digested in water, furnishes a means to destroy flies. The liquor is however, poisonous, and much care should be observed in using it.

FLIES, to destroy. Various means have been used to kill flies, and generally fly-stone has been used for this purpose. This stone or ore, is pulverized, and put into water; which dissolves the arsenic contained in it, and communicates a deleterious quality to the water. Various bitter decoctions have also been employed. Tromsdorf recommends a solution of the extract of quassia, made of two drachms of the extract and half a pint of boiling water, sweetened with sugar, which is then poured on plates. If the atmosphere of a room be impregnated with the smell, or smoke produced by burning the dried leaves of the gourd (*cucurbita*, L.) the flies will immediately be expelled.

FOIL, among glass grinders, a sheet of tin, with quicksilver or the like, laid on the back side of a looking-glass, to make it reflect. See Foliating and Silvering.

FOIL, among jewellers, a thin leaf of metal placed under a transparent stone, in order to reflect certain coloured rays. These foils are made of different metals. The copper foils are commonly known by the name of Nuremberg or German foils; and are prepared as follows: Procure very

thin copper plates and polish them. Place them between two iron plates as thin as writing paper, and heat them in the fire. Boil the foil in a pipkin containing a solution of common salt and cream of tartar, till it becomes white. The foil being thus prepared, and of a sufficient thinness, is next to be polished, which is done by rubbing it on copper in contact with chalk.

FOLIATING of looking-glasses. This is a process which consists in covering the back side of looking-glasses, with tin foil, in order to reflect the image, and is performed in the following manner; a thin blotting paper is laid on the table, and sprinkled with fine chalk, and then a fine lamina or leaf of tin, called foil, is laid over the paper: upon this is poured mercury, which is to be distributed equably by a hare's foot or cotton: over this is laid a clean paper, and over that the glass plate, which is pressed down with the right hand, and the paper drawn gently out with the left: this being done, the plate is covered with a thicker paper, and loaded with a greater weight, that the superfluous mercury may be driven out, and the tin adheres more clearly to the glass. When it is dried, the weight is removed, and the looking-glass is complete. This subject, however, will be noticed hereafter.

FOILING, of globe looking-glasses is performed with an amalgam of 5 ounces of mercury, one ounce of bismuth, half an ounce of lead and the same quantity of tin.

FOUNDERY or **FOUNDRY**, the art of melting and casting all sorts of metals; particularly brass, iron, bell-metal, &c. A foundery, in the iron manufacture, is almost always connected with the blast furnace, where the metal is smelted from the ore. The casting-house, as it is also called, or foundery, is situated on one of the sides of the furnace, the surface of its ground about two feet below the level of the bottom of the hearth of the furnace. The floor of the foundery should be about ten feet deep, with the loamy sand, of which the moulds are formed; this is for the convenience of burying large moulds beneath the surface, so that the metal may be conveyed into them by small channels or soughs hollowed out in the sand. A most important circumstance to be attended to is, that the foundery is well drained of water, as any dampness in moulds would produce the most fatal explosions by the sudden expansion of the steam. When the hot metal is introduced into a wet mould many serious accidents have arisen from a want of attention to this very necessary circumstance; in such a case, the moulds are burst asunder, the ground torn up, and the fluid metal thrown in every direction amongst the workmen, occasioning as much damage from its projectile force, as from its great heat, to those on whom it falls. Every foundery is furnished with a crane, or sometimes two, placed so as to command the whole for the convenience of taking up and removing heavy pieces of casting from any part of the place.

The most complete founderies are provided with two or more, air or reverberating furnaces, in which the metal is melted occasionally, either when the metal contained in the blast furnace is not sufficient, or when the quality of the metal made there is not proper for casting, owing to its containing too much or too little carbon, and it requires mixing with better or worse metal to render it fit for the purpose.

They have also two or three cupolas, or small blast furnaces, to melt small quantities of metal, particularly when it is wanted in haste, as the reverberatories are much longer in filling their charge of metal, though it is in greater quantity, but the latter does not so well answer the purposes of the iron founder, because it would require so great a stock of flasks and implements to make moulds to receive a large quantity of metal; for this reason they seldom employ the reverberatory but for large articles which require the whole charge; smaller goods are cast from the cupolas.

In the foundery of a blast furnace, a pit is sunk at a convenient distance from the furnace, and the moulds for pipes, and other similar articles, are placed vertically in it, within reach of the crane: the metal is conveyed by gutters or soughs from the furnace, and a small iron trough filled with sand, leads the fluid metal into each of the moulds; these are a considerable improvement on the old method of burying them in the sand, in the saving of labour and time; the flasks are made of cast iron for the purpose.

It has of late become a practice at extensive founderies, to substitute sand for loam castings in many cases where a great number of articles of one kind are to be cast, so that the expense of the flasks is not an object of importance; where the articles are intricate, the sand is wetted so much to render it sufficiently adhesive, that it is necessary to dry the moulds to avoid the danger of an explosion: for this purpose large stoves are used, and carriages adapted, on which to convey a great number of moulds into the stove at

once, and when sufficiently dry, which generally happens in about half an hour, they are withdrawn, and a new set placed on the carriage.

A foundery is generally provided with a boring-mill for forming the internal surface of the cylinders cast for steam-engines, &c. and the same machinery turns large lathes, for turning heavy mill-axes, pistons, rollers for sugar-mills, and laminating rollers; the same mill gives motion to all these, and also blows the cupolas, though, at a blast-furnace, these are supplied by a small pipe from the great blowing-engine for the furnace.

With respect to casting of every description, whether of iron, brass or other materials, for the purpose of cannon, bells, steam cylinders, machinery, &c. We may add, that the United States in this as in other arts, have long since vied with the European nations This reflects much honor on the zeal and industry of our countrymen.

We shall first consider the foundery of small works, then of statues, guns, &c. and lastly of the type or letter foundery, reserving for other parts of our work more particular information.

Foundery of small works or the manner of casting in sand.—The sand used by the founders, in casting brass, &c. is yellowish, and pretty soft; but, after it has been used, it becomes quite black, because of the charcoal-dust used in the moulds. Every time they would use this sand, they work and tew it, several times over, on a board about a foot square, placed over a kind of trunk, or box, into which it may fall from off the board. This tewing is performed with a roller, or cylinder, about two feet long, and two inches in diameter; and a kind of knife, made of the blade of a sword: with these two instruments they alternately roll and cut the sand; and, at length, turn it down into the box or trough underneath.

Then, taking a wooden board, or table, of a length and breadth proportional to the quantity of things to be cast; round this they put a frame or ledge; and thus make a sort of mould. This mould they fill with the sand before prepared, and moderately moistened: which done, they take wooden, or metalline models, or patterns of the things intended to be cast: apply them on the mould, and press them down in the sand, so as to leave their form indented; along the middle of the mould is laid half a little cylinder of brass, which is to be the master jet, or canal for running the metal; being so disposed, as to touch the ledge on one side, and only to reach to the last pattern on the other: from this are placed several lesser jets or branches, reaching to each pattern, whereby the metal is conveyed through the whole frame.

This first frame being thus finished, they turn it upside down, to take out the pattern from the sand; in order to which, they first loosen them a little all round, with a small cutting instrument.

After the same manner they proceed to work the counterpart, or other half of the mould, with the same patterns, in a frame exactly like the former; excepting that it has pins, which entering holes corresponding thereto in the other, make, when the two are joined together, the two cavities of the pattern fall exactly on each other.

The frame, being thus moulded, is carried to the founder or melter; who, after enlarging the principal jet, or canal, of the counter-part with a kind of knife, adding the cross jets, or canals, to the several patterns in both, and sprinkling them over with mill-dust, sets them to dry in an oven.

When both parts of the mould are sufficiently dried, they join them together, by means of the pins; and to prevent their starting, or slipping aside, by the force of the metal, which is to come in flaming hot, through a hole contrived at the master-jet, they lock them in a kind of press, either with screws; or if the mould be too big for this, with wedges. The moulds, thus put in the press, are ranged near the furnace, to be in readiness to receive the metal as it comes out of the crucible.

While the moulds are thus preparing, the metal is put in fusion in an earthen crucible, about ten inches high, and four in diameter.

The furnace wherein the fusion is made, is much like the smith's forge; having, like that, a chimney, to carry off the smoke; a pair of bellows to blow up the fire; and a hearth where the fire is made, and the crucible placed. It is the use of this hearth, that chiefly distinguishes the furnace from the forge

In the middle thereof is a square cavity, ten or twelve inches wide, which goes to the very bottom: it is divided into two, by an iron grate: the upper partition serves to hold the crucible, and the fuel, and the lower to receive the ashes.

When the fuel, which is to be of dry wood, is pretty well lighted, they put the crucible full of metal in the middle, and cover it with an earthen lid; and, to increase the force of the fire, besides blow-

ing it up with the bellows, they lay a tile over part of the aperture or cavity of the furnace.

The metal first put in being brought to a fusion, they fill the crucible with pieces of brass, beaten in a mortar; to put them in, they make use of a kind of iron ladle, with a long shank at the end thereof, formed into a kind of hollow cylinder, out of which the piece is dropped.

Nothing now remains, but for the founder to take the crucible out of the fire, and carry it in a pair of iron tongs (whose feet are bent, the better to embrace the top of the crucible) to the mould; into which he pours the melted metal, through the hole answering to the master-jet of each mould.

Thus he goes successively, from one to another, till his crucible is emptied, or there is not matter enough left for another mould.

Then casting cold water on the moulds, they take the frames out of the presses, and the cast works out of the sand, which, afterwards, they work again, for another casting. Lastly, they cut off the jets, or casts, and sell or deliver the work to those who bespoke it, without any farther pairing.

Foundery *of statues, great guns, and bells.*—The art of casting statues in brass is very ancient; insomuch, that its origin was too remote and obscure, even for the research of Pliny; an author admirably skilled at discovering the inventors of other arts.

All we can learn for certain is, that it was practised, in all its perfection, first among the Greeks; and, afterwards, among the Romans: and, that the number of their statues consecrated to their gods and heroes, surpassed all belief. See Statue.

The single cities of Athens, Delphos, Rhodes, &c. had each three thousand statues; and Marcus Scaurus alone, though only ædile, adorned the circus with no less than three thousand statues of brass, for the time of the Circensian games. This taste for statues was finally carried to such a pitch, that it became a proverb, that in Rome, the people of brass were not less numerous than the Roman people.

The casting of statues was but little known or practised in Europe, before the seventeenth century.

As to the *casting of guns*, it is quite modern; and it were perhaps to be wished, we were as ignorant of it as the ancients. All authors agree, that the first cannon were cast in the fourteenth century; though some affix the event to the year 1338, and others to 1380.

The *casting of bells* is of a middle standing, between the other two. The use of bells is certainly very ancient in the western church; and the same were likewise once used in the church of the east. But, at present, F. Vansleb assures us, in his second account of Egypt, that he had found but one bell in all the eastern church, and that, in a monastery in the Upper Egypt.

The matter of these large works is rarely any simple metal, but commonly a mixture of several. We shall here give the process in the foundery of each.

Method of casting statues of figures.

There are three things chiefly required in casting of statues, busts, basso-relievos, vases, and other works of sculpture: viz. the mould, the wax, and shell, or coat. The inner mould, or core (thus called from *cœur*, as being in the heart or middle of the statue), is a rude lumpish figure, to which is given the attitudes and contours of the statue intended; it is raised on an iron grate, strong enough to sustain it; and is strengthened withinside by several bars, or ribs of iron.

It may be made, at the discretion of the workmen, of potters' clay, mixed up with horse-dung and hair; or, of plaister of Paris, mixed with fine brick-dust.

The use of the core in statues, is to support the wax and shell, to lessen the weight, and to save metal. In bells, it takes up all the inside, and preserves the space vacant where the clapper is hung. In great guns it forms the whole chace, from the mouth to the breech: and, in mortars, the chace and chamber. The iron bars and the core are taken out of the brass figure, through an aperture left in it, which is afterwards soldered up: but it is necessary to leave some of the iron bars of the core that contribute to the steadiness of the projecting parts, within the brass figure.

The wax is a representation of the intended statue. If it be a piece of sculpture, the wax must be all of the sculptor's own hand, who usually fashions it on the core itself; though it may be wrought separately in cavities, moulded, or formed, on a model, and afterwards disposed and arranged on the ribs of iron over the grate, as before, filling the vacant space in the middle with liquid plaister and brick-dust; by which means the inner mould, or core, is formed in proportion as the sculptor carries on the wax.

When the wax which is to be of the intended thickness of the metal is finished, they fix little waxen tubes perpendicularly to it, from top to bottom; to serve, both as jets, for the conveyance of metal

to all parts of the work, and as vent holes, to give passage to the air, which would, otherwise, occasion great disorder, when the hot metal came to encompass it. By the weight of the wax used herein, is that of the metal adjusted; ten pounds of this last being the proportion to one pound of the former. The work brought thus far, wants nothing but to be covered with its shell; which is a kind of coat, or crust, laid over the wax: and which, being of a soft matter, and even, at first, liquid, easily takes and preserves the impression of every part thereof, which it afterwards communicates to the metal, upon its taking the place of the wax, between the shell and the core. The matter of this outer mould, or shell, is varied according as different layers, or strata are applied. The first is a composition of clay, and old white crucibles, well ground and sifted, and mixed up with water, to the consistence of a colour fit for painting: accordingly, they apply it with a pencil, laying it seven or eight times over, letting it dry between the intervals. For the second impression, they add horse's dung and natural earth to the former composition. The third impression is only horse's dung and earth. Lastly, the shell is finished by laying on several more impressions of this last matter, made very thick with the hand.

The shell, thus finished, is secured and strengthened by several bands, or girts of iron, wound around it at half a foot's distance from one another, and fastened at bottom to the grate under the statue; and at the top to a circle of iron, where they all terminate.

Here it must be observed, that if the statue be so big, that it would not be easy to move the moulds, when thus provided, it must be wrought on the spot where it is to be cast.

This is performed two ways; in the first, a square hole is dug under ground, much bigger than the mould to be made therein, and its insides lined with walls of freestone, or brick. At the bottom is made a hole of the same materials, with a kind of furnace, having its aperture outwards: in this is a fire to be lighted, to dry the mould; and afterwards, to melt the wax. Over this furnace is placed the grate; and on this the mould, &c. framed as before explained. Lastly, at one of the edges of the square pit is made another large furnace, to melt the metal, as hereafter mentioned.

In the other way, it is sufficient to work the mould above ground: but with the same precaution of a furnace, and grate, underneath: when finished, four walls are to be run up round it: and, by the side thereof, a massive made, for a melting-furnace. For the rest, the method is the same in both. The mould being finished, and inclosed between four walls, whether under ground, or above it, a moderate fire is lighted in the furnace under it, and the hole covered with planks, that the wax may melt gently down, and run out at pipes contrived for the purpose, at the foot of the mould; which are afterwards very exactly closed with earth, as soon as all the wax is carried off.

This done, the hole is filled up with bricks thrown in at random, and the fire in the furnace is augmented till such time as both the bricks and the mould become red-hot; which ordinarily happens in twenty-four hours. Then, the fire being extinguished, and every thing cold again, they take out the bricks, and fill up their place with earth, moistened, and a little beaten, to the top of the mould, in order to make it the more firm and steady.

Things being in this condition, there remains nothing but to melt the metal, and run it into the mould; this is the office of the furnace above, which is made in manner of an oven, with three apertures; one to put in the wood; another for a vent; and a third to run the metal out at. From this last aperture, which is kept very close whilst the metal is in fusion, a little tube or canal is laid, whereby the melted metal is conveyed into a large earthen bason over the mould; into the bottom of which all the big branches of the jets, or casts, which are to carry the metal into all the parts of the mould, are inserted.

It must be added, that these jets are all terminated, or stopped with a kind of plugs, which are kept close, that upon opening the furnace the brass, which gushes out like a torrent of fire, may not enter any of them till the bason be full enough of matter to run into them all at once; upon which occasion they pull out the plugs, which are long iron rods, with a head at one end, capable of filling the whole diameter of each tube. The hole of the furnace is opened with a long piece of iron, fitted at the end of a pole; and the mould is then filled in an instant. The work is now finished, at least so much as belongs to the casting, the rest being the sculptor's or carver's business; who, taking the figure out of the mould and earth with which it is encompassed, saws off the jets, wherewith it appears covered over; and repairs it, with instruments proper to his art; as chisels, gravers, puncheons, &c.

The manner of casting bells.—What has been hitherto shewn of the casting of statues, holds, in proportion, of the casting of bells; that which is particular in these latter is as follows: first, then, the metal is different; there being no tin in the metal of statues, but no less than a fifth part of tin in that of bells. Secondly, the dimensions of the core, and the wax of bells, especially if it be a ring of several bells that is to be cast, are not left to chance, or the caprice of the workmen; but must be measured, on a kind of scale, or diapason; which gives the height, aperture, and thickness, necessary for the several tones required.

It need not be added, that it is on the wax that the several mouldings and other ornaments, and inscriptions, to be represented in relievo, on the outside of the bell, are formed. The clapper or tongue, is not properly a part of the bell, but is furnished from other hands. In Europe, it is usually of iron, with a large knob at the extreme; and is suspended in the middle of the bell. In China, it is only a huge wooden mallet, struck by force of arm against the bell; whence they can have but little of that consonancy, so much admired in some of our rings of bells. The Chinese have an extraordinary way of increasing the sound of their bells; viz. by leaving a hole under the cannon; which our bell-founders would reckon a defect.

The proportions of our bells differ very much from those of the Chinese. In our's, the modern proportions are, to make the diameter fifteen times the thickness of the brim, and the height twelve times. The parts of a bell are, 1. The sounding bow, terminated by an inferior circle, which grows thinner and thinner. 2. The brim or that part of the bell whereon the clapper strikes, and which is thicker than the rest. 3. The outward sinking of the middle of the bell, or the point under which it grows wider to the brim. 4. The waist of furniture, and the part that grows wider and thicker quite to the brim. 5. The upper vase, or that part which is above the waist. 6. The pallet which supports the staple of the clapper within. 7. The bent and hollowed branches of metal uniting with the cannons, to receive the iron keys, whereby the bell is hung up to the beam which is its support and counterpoise, when rung out. The business of bell-foundery is reducible to three particulars. 1. The proportion of a bell. 2. The forming of the mould. And, 3. The melting of the metal. There are two kinds of proportions, viz. the simple and the relative; the former are those proportions only that are between the several parts of a bell to render it sonorous; the relative proportions establish a requisite harmony between several bells. The method of forming the profile of a bell, previously to its being cast, with the proportion of the several parts may be seen in Rees's Cyclopædia.

The particulars necessary for making the mould of a bell are, 1. The earth: the most cohesive is the best; it must be well ground and sifted, to prevent any chinks. 2. Brick-stone; which must be used for the mine, mould, or core, and for the furnace. 3. Horse dung, hair, and hemp, mixed with the earth, to render the cement more binding. 4. The wax for inscriptions, coats of arms, &c. 5. The tallow equally mixed with the wax, in order to put a slight layer of it upon the outer mould, before any letters are applied to it. 6. The coals to dry the mould. See Encyclopædia, Art. Cloche, also Dict. Commerc. Art. Foundery.

Foundery. *Manner of casting great guns, or pieces of artillery.*—The casting of cannons, mortars, and other pieces of artillery, is performed much like that of statues and bells; especially as to what regards the wax, shell, and furnaces.

All pieces of artillery are now cast solid, and bored afterwards, by means of a machine invented at Strasburgh, and much improved by Mr. Verbruggen, head founder at Woolwich. The gun to be bored was at first placed in a perpendicular position; but the machines used for this purpose have lately been made to bore horizontally, and much more exactly than those that bore in a vertical situation. Whilst the inside is bored, the outside is turned and polished at the same time.

As to the metal, it is somewhat different from both; as having a mixture of tin, which is not in that of statues; and only having half the quantity of tin that is in bells, *i. e.* at the rate of ten pounds of tin to an hundred of copper. The respective quantities of different metals that should enter into the composition for brass cannon is not absolutely decided; the most common proportions of the ingredients are the following: viz. to 240lb. of metal fit for casting, they put 68lb. of copper, 25lb. of brass, and 12lb. of tin. To 4200lb. of metal fit for casting, the Germans put $3687\frac{33}{41}$lb. of copper, $204\frac{13}{41}$ lb. of brass, and $307\frac{30}{41}$lb. of tin. Others, again, use 100lb. of copper, 6lb. of brass, and 9lb. of tin; and lastly, others make

use of 100lb. of copper, 10lb. of brass, and 15lb. of tin.

A cannon is always shaped a little conical, being thickest of metal at the breech, where the greatest effort of the gunpowder is made, and diminishing thence to the muzzle; so that if the mouth be two inches thick of metal, the breech is six.

Its length is measured in calibers, *i. e.* in diameters of the muzzle. Six inches at the muzzle require twenty calibers or ten feet in length; there is always about the sixth of an inch allowed for play for the ball. The method of casting iron cannon differs very little from that of brass.

Foundery, *Letter, or the method of casting printing Letters.*—In the business of cutting, casting, &c. letters for printing, the letter cutter must be provided with a vice, hand-vice, hammers and files of all sorts for watch makers' use; as also gravers and sculpters of all sorts, and an oil-stone, &c. suitable and sizeable to the several letters to be cut: a flat guage made of box to hold a rod of steel, or the body of a mould, &c. exactly perpendicular to the flat of the using-file: a sliding guage, whose use is to measure and set off distances between the shoulder and the tooth, and to mark it off from the end, or from the edge of the work; a face-guage, which is a square notch cut with a file into the edge of a thin plate of steel, iron, or brass, of the thickness of a piece of common tin, whose use is to proportion the face of each sort of letter, viz. long letters, ascending letters, and short letters. So there must be three guages, and the guage for the long letters is the length of the whole body, supposed to be divided into forty-two equal parts. The guage for the ascending letters, Roman and Italic, are 5-7, or 30 parts of 42, and 33 parts for the English face. The guage for the short letters is 3-7 or 18 parts of 43 of the whole body for the Roman and Italic, and 22 parts for the English face.

The furnace is built of brick upright, with four square sides, and a stone on the top, in which stone is a wide round hole for the pan to stand in. A foundery of any consequence has several of these furnaces in it.

As to the metal of which the types are to be cast, this, in extensive founderies, is always prepared in large quantities; but cast into small bars of about twenty pounds weight to be delivered out to the workmen as occasion requires. For the purpose of forming the metal, a large furnace is built under a shade, containing a pot of cast iron, which holds, when full, fifteen hundred weight of the metal. The fire being kindled below, the bars of lead are let softly down into the pot, and their fusion promoted by throwing in some pitch and tallow, which soon inflame. An outer chimney, which is built so as to project about a foot over the farthest lip of the pot, catches hold of the flame by a strong draught, and makes it act very powerfully in melting the lead; whilst it serves at the same time to convey away all the fumes, &c. from the workmen, to whom this laborious part of the business is committed. When the lead is thoroughly melted, a due proportion of the regulus of antimony and other ingredients are put in, and some more tallow is inflamed, to make the whole incorporate sooner. The workmen now having mixed the contents of the pot very thoroughly, by stirring long with a large iron ladle, next proceed to draw the metal off into the small troughs of cast iron which are ranged, to the number of fourscore, upon a level platform, faced with stone, built towards the right hand. In the course of a day fifteen hundred weight of metal can be easily prepared in this manner; and the operation is continued for as many days as are necessary to prepare a stock of metal, of all the various degrees of hardness. After this the whole is disposed into presses, according to its quality, to be delivered out occasionally to the workmen.

With respect to the operations of casting, polishing, and finishing of type, we need only mention, that these different processes are performed by workmen and boys, according to the nature of the operation. As a mere description of the mechanical part of the type foundery cannot be considered of any importance, it is presumed that the act in all its branches will only be conducted by experienced workmen, so that any description which we might offer would be unnecessary. To the real talents and industry of Messrs. Binney and Ronaldson, of this city, the country at large, is much indebted for the production of every species of type of the best metal, and, of the most improved kind.

Besides the founderies already enumerated, there is another called the *Military Foundery*, which comprehends the casting of military arms, great guns, shells, ball, &c.

The United States, either by their own foundery, have these articles cast, or procure them by contract: it may be observed, however, that a work of this descrip-

tion should be established, for the sake of economy, as well perhaps as for convenience, in the vicinity of coal and iron mines.

FRANKFORT BLACK.—This black is made of the lees of wine, burnt, washed in water, and ground in mills, together with ivory or peach stones burnt.

It is usually brought from Frankfort on the Mayn; Mentz, and Strasburg; either in lumps or powder. That of France, on account of the difference in the lees of wine, is less valued than that of Germany.

This black makes the principal ingredient in the rolling-press printers ink. See COLOUR-MAKING.

FREEZING.—This process, called also congelation, is the conversion of water to a solid state or ice, and takes place by the reduction of temperature to, or be-below 32° of Fahrenheit; the theory of which is the disengagement of free heat, or caloric of fluidity.

Without detailing the hypotheses of chemical philosophy, or the reasoning of science to develope the laws or principles which govern these changes, it will be sufficient to observe, that solids are rendered fluid by the interposition or absorption of caloric, and *vice versa*. Whether these changes take place in the laboratory of the chemist, or in the laboratory of nature, as the same causes exist, it is but rational to conclude that the laws are uniformly the same.

We shall first make a few remarks on ice or snow, and conclude with the modes which have been used for preparing ice in warm climates.

The preservation of snow or ice during the summer months is almost a necessary of life in hot countries, and an object of useful luxury in temperate climates. The construction of ice-houses is in general very simple often indeed they consist of nothing more than deep caves hollowed out in the coldest side of mountains, and filled with ice or snow rammed down with much manual labour. Ice may generally be preserved during the summer, if the place selected be cool and thoroughly sheltered from the direct influence of the sun, if the ice be kept in considerable mass, with as few interstices as possible, lined with straw, reeds, or any loose substance of the kind, which is a bad conductor of heat, and especially if it be kept dry both by avoiding external moisture and by giving an exit to the water formed by the slow liquefaction of the outer part of the mass. The common ice-houses are usually placed in the shadiest and coolest part of a wood, and consist of caves about eight or ten feet in depth, lined with masonry, unless cut out of a dry rock, finished at the bottom in the form of a sugar loaf, and the whole lined with a considerable thickness of thatch, straw, or reeds. The ice when thrown in is broken down as much as possible, that it may lie close, and when filling, water may be thrown on it, which by freezing will cement the whole into a hard solid mass penetrable only by the pickaxe. When filled it is covered very carefully with earth and thatch, leaving only a small entrance with a door at each end also very closely lined.

The snow caves in Italy are no more than deep pits dug in the north side of a hill, lined with straw, and furnished with a small tap-hole at bottom to carry off the water formed by melting. The snow is rammed very hard, and if well laid up will keep during the whole summer.

But in tropical climates far distant from high mountains, as neither natural snow nor ice can be obtained, recourse is had to the cold generated by evaporation and the comparative coolness of the air a little before day-break, to manufacture ice in large quantities, and thus to supply a most grateful luxury at a moderate price. Ice is thus simply manufactured in the large way at Benares, Allahabad, and Calcutta, where natural ice has never been seen. On a large open plain an excavation is made about thirty feet square and two deep, on the bottom of which sugar-cane or maize stems are evenly strewed to the height of about eight inches. On this bed are set rows of small shallow unglazed earthen pans, so porous that when filled with water the outsides are immediately covered with a thick dew oozing through them. Towards the dusk of the evening, the pans previously smeared with butter, are filled with soft water generally boiled, and let to remain there during the night. In the morning before sun-rise the ice-makers attend and collect from each pan a crust of ice more or less thick that adheres to the inner side, and is put into baskets and carried without loss of time to the common receptacle, which is a deep pit in a high dry situation, lined first with straw and then with old blanketing, where it is beaten down and congeals into a solid mass. The crop of ice varies extremely, sometimes amounting to more than half the contents of the pan, at other times scarcely a pellicle. Clear and serene weather is the most favourable for its production whatever be the sensible heat of the atmosphere. The cold generated by the rapid evaporation round every part of the pan is the cause of this congelation. When used for the ta-

ble, the ice is either added to the liquor to be cooled, or is put into a large vessel mixed with salt or nitre, and the sherbet, creams, and the like, intended to be frozen, are inclosed in thin silver vessels and immersed in the mixture. In this way ices are procured for the table, when the heat even in the shade is very commonly above 100°.

At the ice manufactory at Benares about 100,000 pans are reckoned to be exposed at a time, and the business of filling them at night and gathering the ice in the morning employs about 300 men, women, and children.

It is necessary that the cane-stalks be kept perfectly dry, if by accident any part becomes wetted, no ice will form in the pans above.

Mr. Williams found the temperature of the air on the cane-stalks never to be lower than 36°, and even plenty of ice would form in the pans when it was as high as 40°. What is remarkable, he found that ice was best formed with the gentlest winds, at which time a thermometer placed on the straw would always stand about 4 degrees lower than one fixed to a pole five feet higher, but in strong winds no such difference was observable, and then no ice was formed.

To compare the effect of the porosity of these vessels in lowering the temperature of water contained in them, Mr. Williams took a new pot and one in which by long use the pores had been nearly stopped, and placed them in a hot westerly wind in the shade, where the heat of the air was 100°. On exposure for four hours the water in the old pot was 97, and that in the new pot was only 68°.

Many other instances of artificial cold produced by evaporation might be brought.

Another mode of producing cold is by freezing mixtures, or saline substances of various kinds, which, during their liquefaction either by solution in water or in acids, absorb a vast quantity of caloric from all substances in contact with them.

This subject, however, in its extent, would lead us beyond our limits.

FRENCH CHALK. See STEATITE.

FRENCH BERRIES. The fruit of the *Rhamnus infectorius*, called by the French *graines d'Avignon*. They give a pretty good yellow colour, but void of permanency. See DYEING.

FRICTION. If a horizontal plane was perfectly smooth, a body would be free to move upon it in any direction, by the least force applied to it. But however smooth bodies may appear to the eye, yet, if you examine their surfaces with a microscope, you will discover numberless inequalities; in consequence of which, the prominent parts of one body fall into the hollows of another, so as to be locked together; and therefore, in moving them over each other, one of the bodies must be raised up, or its prominences broken off: this is what is called *friction*.

Friction is greater in bodies, in proportion to their weight or pressure against each other. It does not increase much in proportion to the surface, although it does in some degree. It also increases in proportion to the velocity of the moving bodies.

Wood slides more easily upon the ground, or earth, in wet weather than in dry, and more easily than iron in dry weather, but iron more easily than wood in wet weather. A cubic piece of smooth soft wood, eight pounds in weight, moving upon a smooth plane of soft wood, at the rate of three feet every second, has a friction equal to above two-thirds of its weight. Soft wood upon hard wood, has a friction equal to one-sixth part of its weight; and hard wood upon hard wood, has a friction equal to about one-eighth part of its weight.

In wood rubbing upon wood, oil, grease, or black-lead, properly applied, makes the friction two-thirds less. Wheel-naves, when greased, have only one-fourth of the friction they would have if wet.

When polished steel moves on steel, or pewter properly oiled, the friction is about one-fourth of the weight; on copper or lead, one-fifth of the weight; on brass, one-sixth; and metals have more friction when they move on metals of the same kind, than when they move on different metals.

The friction of a single lever is very little. The friction of the wheel and axle is in proportion to the weight, velocity, and diameter of the axle; the smaller the diameter of the axle, the less will be the friction.

The friction of pullies is very great, on account of the smallness of their diameters, in proportion to that of their axes; because they very often bear against the blocks, and from the wearing of their holes and axles.

In the wedge and screw there is a great deal of friction.

Screws with sharp threads, have more friction than those with square threads, and endless screws have more than either.

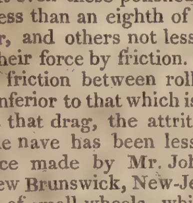
The friction of carriage wheels is much further increased, if they be tacked or fastened so that they drag upon the surface of the road; it is, therefore, to increase the resistance by augmenting the

friction, that a wheel is locked in descending steep hills, where the relative gravitation gives too much velocity to the carriage.

Friction is considered as an uniformly retarding force in hard bodies, and not subject to alter by different degrees of velocity; it increases in a less ratio than the quantity of matter, or weight of the body; and the smallest surface, or the fewest parts in contact, have the least friction, the weight being the same.

The force or power of friction varies, in proportion to the different surfaces in contact; that is, accordingly as the surfaces are hard or soft, rough or smooth; even the hardest bodies which have the highest polish are not free from inequalities on their surface, which retard their motion when they act upon each other. When polished iron and bell-metal are opposed to each other in motion, they produce less resistance than bodies in general; but even these polished planes do not lose less than an eighth of their moving power, and others not less than one-third of their force by friction.

As the friction between rolling bodies is much inferior to that which is produced by bodies that drag, the attrition of the axle in the nave has been lessened by a contrivance made by Mr. John Garnet, now of New Brunswick, New-Jersey, with a number of small wheels, which are called friction rollers; these are placed together in a box, and fastened in the nave so that the axle of the carriage may rest upon them, and they turn round their own centres as the wheel continues its motion. A represents a section of the axle, C C the nave, and B B the friction rollers which turn round their own axis as the wheel revolves round the axle of the carriage.



Cylindrical and spherical rollers are used with great advantage in turning heavy bodies, such as the top of a wind-mill or the dome of an observatory; or in moving large logs of wood or blocks of stone from one place to another. The grand equestrian statute of Peter the Great, at Petersburgh, was formed out of an immense block of stone, which was brought from a place some miles distant, by rolling it along the road on iron balls laid on thick planks.

Mr. Vince and Mr. Coulombe made a number of experiments on this subject. The experiments of the former were made to determine. 1. Whether friction be a uniformly retarding force. 2. The quantity of friction. 3. Whether the friction varies in proportion to the pressure of the weight. 4. Whether the friction be the same, on whichsoever surfaces the body moves. His conclusions, however, were far from being precisely acurate, owing to the resistance which arises from cohesion.

To have the friction of machines as little as possible, they ought to be made of the fewest and simplest parts. The diameters of the wheels and pullies ought to be large, and the gudgeons of the axles as small as can be consistent with the required strength. The sides of the pullies ought not to be all over flat, but to have a small rising in the middle, to keep from rubbing against each other's sides, and against the sides of their mortises at a distance from their axle. All the cords and ropes ought to be as pliant as possible; and, for that end, rubbed with grease. The teeth of the wheels should just fit and fill the openings, so as not to be squeezed nor shaken therein. All the parts which work into or upon one another, ought to be smooth; the gudgeons ought just to fit their holes, and the working parts must be greased. The rounds or staves of the trundles may be made to turn about upon iron spindles, fixed in the round end-boards; which will take off a great deal of friction.

Friesland Green. An ammonia comuriat of copper, the same with Brunswick green. See COPPER, and COLOUR MAKING.

FRITT. The materials of glass are first mixed together, and then exposed to calcination by a degree of heat not sufficient to melt them. The mass is then called fritt. The calcination deprives it of any accidental combustible matter it might have contained, and disposes it to fusion in the melting-pot with less effervescence than would else have taken place. See GLASS.

FRUITS, *Colours from.* It is well known, that a variety of fruits, as the poke berry, currant, mulberry, black cherry, &c. yield a juice which has the property of giving a fugitive colour to linen and the like. Upon these juices various chemical reagents have different ef-

fects: Thus, upon some, acids heighten the colour, and alkalies strike a purple. Whiting soaked in the juice of some of these fruits, is changed into a pigment of a beautiful colour, but which is liable to fade. See Colour Making. Mr. Lindo, of South Carolina, made some experiments with the juice of the poke berry, in order to fix it with the substance of cotton, which succeeded only in part. Dr. Seybert, some time since, made a number of experiments on the poke berry; and, after trying as many as twenty fluids, either acid, alkaline, earthy, or metallic, no permanency could be given to the colour. We have also tried a number, but not with much success. It is said, however, that a Mr. Allison, I think in New Jersey, has discovered a process, or mordant, by which the colour may be indelibly fixed on stuffs. If this be true, the poke berry, which abounds so plentifully in the United States, will prove an acquisition to our country.

The fruit, as it may be termed, of the Lombardy poplar, which communicates a purple to the skin, may be fixed pretty permanently by means of a solution of tin, or of alum, to which potash is afterwards added.

In Dr. Lewis's examination of the colouring matters of vegetable fruits, he found, that the red juices of fruits did not afford a permanent dye by any treatment he used. The dark dull stain of the black cherry proved considerably durable. Sap Green is prepared from the berries of buckthorn, and Annotto is obtained from the pellicles of the seeds of an American tree. See Sap Green and Annotto.

FUEL, whatever is proper to burn, or make a fire; as wood, turf, peat, coal, &c.

FUEL, *Economy in.* Nothing is of more importance, where fuel is scarce and consequently high, than economy in the use of fuel. In order to economize in the article of coal, count Rumford long since turned his attention to this subject, and has proposed a composition, which is to be made into balls, composed of equal parts of coal, charcoal, and clay. If balls be made of this mixture, and afterwards soaked in a solution of saltpetre, they will instantly take fire from the smallest spark. The patent coal balls, invented by Mr. Frederic, are of a similar kind. A mixture of coke and charcoal, or of sea coal, charcoal, saw dust, tan, &c. after being heated in a furnace, form the improved fuel invented by Mr. Peter Davey. Various patents have been obtained for the means of saving fuel, for the purposes of salt making, sugar refining, boiling, distilling, evaporating, and for every process in which fuel is necessary.

In the kitchen, also, contrivances have been used for the same purpose: To this subject, in particular, too much attention cannot be given. Among the means of economizing fuel already carried into effect in Europe, principally at the instance of sir Benjamin Thompson, we may mention also the improvements of our countrymen. In justice to one, in particular, (Mr. Daniel Pettibone,) to whom we are indebted for sundry improvements in this way, our country has already received considerable advantages.

Dr. Franklin, however, may be said to be the first, in the then colonies of America, who applied himself to these improvements, and the construction of stoves. In relation to this subject, Mr. Pettibone obtained the following patents:

1. A wheel oven, or stove, called a perpetual oven, which is useful in an army. It moves by weights.

2. A ship's camboase, with many advantages.

3. A furnace, or stove, made of iron or copper, with a grate, consisting of hollow bars.

4. An improvement on all kinds of pots, kettles, or boilers whatever, by adding or attaching a hoop to the sides, near the bottom, thereby confining the heat to it: the contents will boil in half the usual time required without the hoop. This improvement is useful for camp kettles, or washing rooms.

5. An improvement in the common tin kitchen, or roaster.—Cover the back and top with a thick soft woollen blanket; or, to make the kitchen durable, leave a dead column of air between.

6. A rarifying air stove, for sundry purposes.

These, with other patents, are described in Pettibone's *Economy of Fuel.*

On the subject of the kitchen stove, &c. Mr. Pettibone observes:

"I contemplate the application of a bellows to blow into a stove, camboase, furnace, or a number of small furnaces, somewhat similar to those of *count Rumford's;* which improvement I call the

"*Improved Kitchen Range, Furnace, Stove, and Camboase.*—This improvement consists in placing a bellows, similar to that of a smith's, in any convenient part of a house, or building, and conveying air from it, by a pipe or tube, to the stove furnace, furnaces, or range.—And from the main air-tube, other branches or tubes are fitted with cocks, so as to admit air into any single stove or furnace, or into all the furnaces at one and the same time.

"By this means, stone or other coal, or wood, may be used to great advantage.—The fire can be immediately kindled or extinguished.—These furnaces are fitted without grates, and with grates, that the fire may be kindled by the air of the room, or from the cellar, or from without the house, when only a slow and moderate heat is required, as in common.

"The application of the bellows, as above mentioned, is of great use, particularly in the summer, for domestic purposes, as the common furnaces are not apt to kindle or draw well, for want of a full supply of air. By this plan of the improved kitchen, cast or wrought iron heaters, of a proper size, may be heated, so as to prepare tea, or coffee, &c. on a table. By putting them in a proper apparatus, prepared to prevent the escape of heat, some kinds of baking can be performed.—This improvement is particularly suitable and well calculated for the camboases of ships or vessels,—as the vessel will work the bellows by its motion, when at sea.

"These stoves, furnaces, or camboases, are made of stone or brick, or, if of cast or wrought iron, they must be lined with brick or stone, to prevent the escape of heat—and a damper is fitted in the smoke pipe or flue, so as to regulate it.

"This plan will be of great advantage, as no more cold air can enter the stove, furnace, or camboos, than is required to kindle or blow the fire.—It will save at least one half the fuel commonly used on board of vessels, or in kitchens."

The most convenient and, we may add, the most economical stove, for the purposes of the kitchen, where fuel is to be saved, is the patent stove of Mr. Abbot, which we shall describe hereafter.

FULIGINOUS. Vapours which possess the property of smoke; namely, opacity, and the disposition to apply themselves to surrounding bodies in the form of a dark-coloured powder.

FULLERS' EARTH. See Earth, Fullers'.

FULLING, sometimes called also milling, is used for cleansing, scouring, and pressing cloths, stuffs, and stockings, to render them stronger and much firmer.

The fulling of cloth is performed in a mill, called a fulling or scouring mill. The stuffs are prepared in a bath of urine, then in fullers' earth, diffused in water; and, lastly, in soap, dissolved in hot water. The scouring of the cloth is not the only object in fulling; but, by the alternate pressure communicated by the stamps to the stuffs, an effect is produced similar to *felting*, which changes the texture of the cloth into a substance analogous to felt.

The *fulling of stockings, caps, &c.* is performed with the feet or hands, or by a kind of rack or wooden machine, armed with teeth. Urine, soap, fullers' earth, &c. are also used in this process. Stockings, however, manufactured in a loom, should be fulled with soap alone; but, if the stockings be knit, earth may likewise be added.

If the earth, known by the name of fullers' earth, cannot be had, it may be remarked, that every fine clay that does not communicate a colour, is in general fit for the business of fulling; even the excrements of hogs, mixed with human urine, are used for this purpose, in various woollen manufactories.

The properties required in good fullers' earth are, that it shall carry off the oily impurities of the woollen cloth, and at the same time thicken it, by causing the hairs or fibres to curl up. The best is composed of fine siliceous earth with clay, and a little calcareous earth. See Manufacture of Cloth.

FURNACE, an article of chemical apparatus, &c. Without entering into a dry detail of the various kinds of furnaces, either used in chemical experiments or in the arts, which we shall notice hereafter, when treating of some particular processes, we may observe, that we have the air furnace, the blast furnace, the reverberatory furnace, &c. Dr. Black's portable furnace appears to be the basis of all the portable chemical furnaces of our day, from which the universal furnace of Accum, Aikin's furnace, &c. have been modelled. The muffle, portable chamber, portable blast, the reverberatory, and the draught melting furnace, have each their several uses. See Appendix.

FUSTET. The wood of the *rhus cotinus*, or Venus's sumach, yields a fine orange colour, but not at all durable. It is used by the French dyers, but we believe not much in this country, with other colouring substances, particularly cochineal, to modify or heighten their effect, and in this way is more permanent. Like the French berries, its colour is soluble both in water and alcohol. Its decoction contains a small portion of gallic acid, but no gum; reduces gold; and precipitates the metallic salts. See Dyeing.

FUSTIC, or Yellow Wood. This wood, the *morus tinctoria*, is a native of the West Indies. It affords much yellow colouring matter, which is very permanent. See Dyeing.

G.

GALENA, sulphuret of lead, or blue lead ore. See Lead.

GALLS, or **GALLNUT**, is the produce of the prickly-cupped oak (Quercus Cerris Linn.) a small timber tree that grows wild in almost all the countries bordering upon the Mediterranean, and in some of the southern provinces of Germany. This substance is said to originate from a puncture made by an insect of the genus cynips, to the young of which, while in their larva state, it serves for habitation and food. It is found adhering to the soft annual shoots of the tree, and in short, in its original situation and general appearance is considered by naturalists as precisely similar to those excrescencies on English oaks, vulgarly called *oak-apples*. There are two kinds of gall-nut distinguished in commerce; the inferior is of a pale brown colour, and about the size of a nutmeg, and is procured from Spain, France, and the northern Mediterranean countries; the superior sort is of a deep olive colour, approaching to black, is smaller than the other, and its specific gravity is considerably greater: it is produced in Asia Minor, but more especially in Syria, and is hence called the Aleppo gall, this town being the principal seat of the foreign Syrian commerce.

Without stating the exact analysis of galls, and without noticing all their chemical properties or characters, we may observe, that they contain a considerable quantity of gallic acid and the tanning principle.

For particulars concerning gall-nut see Gallic Acid, Ink, and Tanning.

The uses of this substance are very important. It is employed largely in dyeing not only blacks and various kindred colours, but is also an essential ingredient in the composition of the finest madder reds.—See Dyeing. It is a necessary part of all the black writing inks: it is employed in the laboratory as a useful test for the salts of iron, and is occasionally used in medicine. As galls are scarce in this country at this time, their place may be supplied, in the opinion of Dr. Penington, altogether, by the pig nut. Many vegetable astringents, which contain an abundance of gallic acid, may be obtained in this country.

GALLIC ACID. If an infusion of galls be exposed to the air, in the course of time a dark-coloured sediment, with small crystals, will be deposited. The latter is gallic acid. If alumine, or a solution of glue, be added to a filtered decoction of galls, the liquor then filtered and evaporated, crystals of the same acid will be obtained.

In consequence of the ready decomposition of this acid and the large proportion of carbon that it contains, it precipitates gold, silver, mercury, copper, bismuth and iron from all their acid combinations, reducing the two first in part to the metallic state. It appears incapable of decomposing the salts of platina, zinc, tin, cobalt, and manganese. The oxygenated salts of iron are thrown down by it, of a deep blue colour spproaching to black, and this is its most characteristic property. It is not used in its pure state, but as a component part of galls and other astringent vegetables. It is applied to a variety of important purposes, for which see especially the articles Dyeing and Ink.

GALLING, an operation in Dyeing, which see.

GALLIUM TINCTORIUM.—This is an indigenous plant, which affords a brilliant red dye. It grows plentifully in some of the middle states, in woods, swamps and on the banks of rivers. So far as we are acquainted with it, and from the fact that the Indians dye all the porcupine quills, and the white hair of deer tails with it, and from the observations of professor Woodhouse, that the dye on cloth and silk is durable, and not changed by any agent except the alkalies, we may

justly infer that it is a valuable plant to the American dyer.

GALVANISM, or GALVANIC ELECTRICITY, called also Voltaism. As no immediate use is made of the science of galvanism in its application to any art, which we at present remember, we shall only offer a few general remarks without detailing the experiments of Galvani, Volta, Davy, and others.

It has been observed, that porter, when drank from a pewter pot, has a superior flavour than when drank out of one of glass or of china. This effect is explained by galvanism. Galvani, however, discovered this principle, if we may so call it, in dissecting a frog, by touching the nerve with his instrument, which, in a particular manner, produced convulsions in the muscles. When zinc and silver are placed on the tongue, so that they may communicate with each other, a peculiar sensation will follow, which is galvanism.

It was afterwards discovered, that plates of zinc, silver, or copper, arranged in a pile with a piece of cloth moistened with salt water between each pair of plates, when arranged properly, would communicate a shock. The apparatus thus found, received the name of the galvanic pile. If the same plates be arranged in an oblong box, the galvanic trough will be formed. The peculiar sensation produced by drinking out of a pewter mug, the discoloration of a silver spoon in the act of eating eggs, and the loosening of the bolts in ships, which have been coppered, by the contact of salt water, with many other phenomena, are resolved into galvanism. For an account of this science, its history, progress, application to experiment, together with the mode of forming piles, batteries, and conducting experiments therewith, we refer the reader to Volta's treatise, 4to. Wilkinson, 2 vol. 8vo. and Davy's Elements of Chemical Philosophy.

GALLEY, an oblong reverberatory furnace, in which a row of retorts is placed beside each other, with their necks protruding through lateral openings.

GAMBOGE, is a concrete vegetable juice, the produce of two trees, both called by the Indians caracapulli (gambogia gutta, Linn.) and is partly of a gummy and partly of a resinous nature. It is brought to us either in form of orbicular masses, or of cylindrical rolls of various sizes: and is of a dense, compact and firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the East Indies, called also Cambodja, and Cambogia; and thence it has obtained its name of cambadium, cambogium, gambogium.

It is a very rough and strong purge: it operates both by vomit and stool, and both ways with much violence, almost in the instant in which it is swallowed, but yet, as it is said, without griping. The dose is from two to four grains as a cathartic; from four to eight grains prove emetic and purgative. The roughness of its operation is diminished by giving it in a liquid form sufficiently diluted.

This gum resin is soluble both in water and in alcohol. Alkaline solutions possess a deep red colour, and pass the filter. Dr. Lewis informs us, that it gives a beautiful and durable citron yellow stain to marble, whether rubbed in substance on the hot stone, or applied, as dragon's blood sometimes is, in form of a spirituous tincture. When it is applied on cold marble, the stone is afterward to be heated to make the colour penetrate.

It is chiefly used as a pigment in water colours, but does not stand.

Gamboge enters into the composition of the gold coloured lacquer; it is also employed by the inlayer and cabinet maker to stain white woods in imitation of box, &c. See VARNISH.

GANGUE. The stones which fill the cavities that form the veins of metals are called the gangue, or matrix of the ore; the rocks that lie over the veins are called the roof; those that lie under them the floor, and by some the hading: the matrix is almost always a finer species of stone than the surrounding rocks, though of the same genus; even the rocks themselves are finer grained as they approach the vein.

There is no matrix peculiarly appropriated to any metal: it has only been remarked, that tin is generally found among stones of the siliceous genus, and lead very frequently among those of the calcareous.

GARNET-COLOUR. See *Colouring of* GLASS.

GARNETS, *to imitate.*—Take prepared crystals two ounces, common red lead six ounces, manganese, 16 grains, zaffre, 3 grains; mix and put them in a crucible; cover it and lute, and set it in a potter's kiln, for twenty-four hours. Or take crystal 2 ounces, minium, 5½ ounces, manganese, 15 grains, zaffre, 4 grains; mix them well together, and let all be baked in a pot well luted, in a potter's kiln for 24 hours. See GLASS.

GAS LIGHT.—The introduction of carbonated hydrogen gas into stores, manufactories, &c. to produce light, under

the name of the *gas light*, has led to the construction of an apparatus for obtaining it from pit coal. It may be proper to mention, that of the combination of carbon and hydrogen, there are several varieties; hence, we have the heavy and light carburetted hydrogen gas, all the varieties of which are inflammable. The gas which rises spontaneously in hot weather from stagnant water, mud, &c. when vegetable and animal matter are in a state of decomposition; that produced by the distillation of acetate of potash, the acid of which by decomposition affords the materials of the gas, and by the distillation of other substances at high or low temperatures, as pit coal, moistened charcoal, wood, &c. to which may be added the decomposition of alcohol by sulphuric acid, in the production of olefiant gas, are all varieties of the same gas. Without stating, however, the particulars on this subject, we shall observe, that pit coal or fossil coal is generally made use of, which is exposed to heat in iron pots or cylinders, and the gas, together with bituminous matter, is conveyed by a pipe into a reservoir, where the tar condenses; the gas is afterwards passed through water, or lime water, in a suitable apparatus, where it is purified; and by a simple contrivance, together with an adjusted pressure, is forced through pipes or tubes into different parts of the building where it is inflamed. The residue, in the distillery vessel, is the same as cake, which may be used as fuel, and the bitumen collected in the receiver, may be employed for sundry purposes. Although the apparatus used in England we think in Soho, as well as in other parts, is rather complicated, and probably answers the purpose very completely, yet trials of the same kind have been made in this country, particularly in Philadelphia, and found to be imperfect. Whether this was owing to any defect in the apparatus, or whether some other cause may be alleged for its failure, we have not ascertained.

It is obvious, that as distillation is the only means of obtaining the gas from pit coal, the more simple the contrivance is, the better; but as a constant supply of gas is necessary, a reservoir is indispensibly requisite, together with stopcocks, pipes with small apertures, &c.

A single experiment will shew the manner in which this gas is produced. Fill the bowl of a common tobacco pipe with powdered pit-coal, cover the mouth over with moistened clay, and expose the bowl to the action of heat; in a short time a yellow-coloured smoke will pass through the stem, which, on applying a lighted taper, will take fire, and thus exhibit the gas light in miniature.

Those who desire information on this subject, in order to introduce the light into manufactories or the like, may find a description of the apparatus, accompanied with a plate, in the third edition of Parke's Chemical Catechism.

GAUZE, a transparent stuff made of silk, and sometimes of thread. See Weaving.

GELATIN, *or animal jelly*.—This is a most abundant principle in a vast variety of the parts of animals, and appears to be one of the great elementary constituents of animal organization. Scarcely any organ is without it, but it is most abundantly contained in skin, in most of the soft and white parts, in bone, and the hard bony horns, in membrane of all kinds, in the blood in small quantity, and also in small proportion as the natural cement of many of the shells.

From all these substances gelatin is extracted simply by boiling in water for a greater or less time, according to the hardness or toughness of the substance employed. This watery solution is transparent and colourless, or nearly so, and when gently evaporated to a small bulk and suffered to cool it *gelatinizes*, or assumes the consistence of cohering, extremely flexible and mobile, soft, tremulous *jelly*, such as is known to every one as prepared for the table.

By further evaporation, the watery solution of gelatin may be rendered hard and brittle, in a degree partly determined by the degree of evaporation, and partly by the original gelatinizing force of the substance that yields it. In this state it forms the solid carpenter's *glue*, or of less stiffness the different kinds of *size* used as cements in so many of the arts. The preparation of these will be described after mentioning some of the chemical properties common to pure gelatine of every description.

The jelly of various animal substances, is prepared for the use of sea-faring persons, under the name of *portable soup*. The whole art of performing this operation consists in boiling the meat, and taking the scum off, as usual, until the soup possesses the requisite flavour. It is then suffered to cool, in order that the fat may be separated. In the next place, it is mixed with five or six whites of eggs, and slightly boiled. This operation serves to clarify the liquid, by the removal of opake particles, which unite with the white of egg at the time it becomes solid by the heat, and are consequently removed

along with it. The liquor is then to be strained through flannel, and evaporated on the water bath to the consistence of a very thick paste; after which it is spread rather thin upon a smooth stone, then cut into cakes, and, lastly, dried in a stove until it becomes brittle. These cakes may be kept four or five years, if defended from moisture. When intended to be used, nothing more is required to be done than to dissolve a sufficient quantity in boiling water, which, by that means, becomes converted into soup.

Jellies are very common in our kitchens; they may be extracted from all the parts of animals, by boiling them in water. Hot water dissolves a large quantity of this substance.

The most singular combination of gelatin, and that which is most useful as a chemical test is with tan. If a solution of gelatin, of glue or isinglass for example, is added to an infusion of oak bark, galls, catechu, or any other vegetable that contains the tanning principle, a copious white precipitate separates, which, when the respective liquors are concentrated, may be collected by the fingers with great ease, and forms a singular grey, ductile mass, smelling like tanned leather, and which dries into a dark brown brittle mass, of the appearance of resin, insoluble in water, and incapable of putrefaction. This combination, which appears to be chemically the same as highly tanned leather, will be further noticed under the article TAN.

The difference in the degree of viscidity and tenacity of the varieties of gelatin, is, as Mr. Hatchett observes, an inherent quality, and not caused by the degree of mere inspissation; otherwise, when each variety was perfectly dry, they would each make a glue, or cement, of exactly the same degree of tenacity, which is known not to be the case. On the contrary, the tenacity depends partly on the age of the animal, the old giving a much stronger glue, *ceteris paribus*, than the young: and partly on the substances that furnish it, the glue from the skin being much stronger than the solid gelatin from the bones, sinews, or any other part. In proportion as the glue is more adhesive, it becomes less easily soluble in water, and absorbs a larger portion before it comes to the state of tremulous gelly. Mr. Hatchett also found that the force of adhesion of the glue from skin was generally proportionate to the toughness of the skin; the soft flexible skins yielding a thinner gelatin than the hard bony skins, and with much more ease.

Glue, such as is made by the carpenters, appears to be made in as great perfection in this as in any other country. The minute circumstances of the operation which give a superiority of the article of one manufacturer over another, cannot be readily ascertained; but, the following is given by Mr. Clennel. as the general mode of manufacture: Glue is an inspissated gelly, made of the parings of hides or horns of any kind, the pelts obtained from furriers, the hoofs and ears of horses, oxen, calves, sheep, &c. These are first digested in lime-water, to cleanse them from grease or dirt, they are then steeped in clean water, with frequent stirring, afterwards laid in a heap, and the water pressed out. They are then boiled in a large brass cauldron, with clean water, skimming off the dirt as it rises; and it is further cleansed by putting in, after the whole is dissolved, a little melted alum, or lime finely powdered. The skimming is continued for some time, after which the mass is strained through baskets, and suffered to settle that the remaining impurities may subside. It is then poured gently into the kettle again, and further evaporated by boiling and skimming, till it becomes of a clear, darkish brown colour. When it is thought to be strong enough, it is poured into frames or moulds, about six feet long, one broad, and two deep, where it gradually hardens as it cools, and is cut out when cold, by a spade, into square cakes. Each of these is placed in a sort of wooden box, open in three divisions to the back; in this the glue, while yet soft, is cut into three slices, by an instrument like a bow, with a brass wire for its string. The slices are then taken out into the open air, and dried on a kind of coarse net-work, fastened in moveable sheds four feet square, which are placed in rows, in the gluemaker's field. When perfectly dry and hard, it is fit for sale. That is thought to be the best glue which swells considerably without melting by three or four days immersion in cold water, and recovers its former dimensions and properties by drying. Glue that has got frost, or that looks thick and black, should be melted over again. To know good from bad glue, the purchaser should hold it between his eye and the light, and if it appears of a strong dark colour, and free from cloudy or black spots, the article is good.

To this distinct and apparently accurate account of glue-making, may be added, some experiments by Pelletier, on a glue from bones, made in France, by a Mr. Greniet, from the raspings and trim-

mings of ivory, the refuse pieces and shavings of the button-mould makers, and other kinds of hard bone, that cannot be turned to account in entire manufacture. Six pounds of button-mould shavings, were put into a copper boiler, with 24 quarts of water, and first let to soak for two hours in the cold. The fire was then kindled, and the liquor slowly brought to boiling, and kept at this heat for 9 hours. After standing a night, 14 quarts of clear gelatinous liquor were drawn off by a syphon, and two quarts more were obtained by pressing the residue. This was duly evaporated without addition, and when of the proper consistence, was allowed to subside for half an hour, when it became firm enough to be cut into cakes, which being then hung up for a fortnight, in a barn, yielded about 15 ounces of solid glue, or rather less than a sixth of the weight of the bone shavings originally used. A similar experiment made with ivory turnings yielded nearly the same proportion of glue. The gelly from these clean white bones, is at first very transparent, and with little colour; but when concentrated by evaporation, it always deepens in colour, but if well made still remains transparent. A piece of this glue put into cold water swelled, as happens with common good glue, and in 24 hours had absorbed 15 times its weight of water; but without dissolving, and by again drying in the air, it returned to its original bulk and weight. It appears that at Paris, there are three sorts of glue commonly sold, the best is that which is imported from England, and is of a deep red; the next in value is the Flemish, which is whitish and transparent; and the most ordinary glue of the country is black and opake.

The Laplanders prepare a glue from the skins of the largest perches.

In using glue, the carpenters first break it and cover it with cold water, and let it stand for about twenty-four hours, by which, as already mentioned, it swells to many times its original bulk, and absorbs a large quantity of this fluid; after which the soaked pieces are melted, without more water, over a slow fire, and kept simmering for about a quarter of an hour with frequent stirring, and are then cooled. It is now a firm gelly, of such a consistence, as very readily to be cut by any instrument, but too still to be tremulous. When wanted to be used, it is merely warmed, which renders it sufficiently fluid to be spread over the surface of the wood with a stiff brush. Wood joined by glue, requires from one to three days to be perfectly cemented, which is known by the hardness of the portion that remains on the outside of the joining; and the force of cohesion of the best glue is such, that boards as thick as any commonly used in furniture carpentry, will full as readily give way by violence in any other part of the substance as at the joining. Glued boards will not set in a freezing temperature, the stiffness being owing to the evaporation of the superfluous water of the glue which is prevented by great cold.

A variety of gelatinous cements of less firmness than common glue, and known by the general term of *Size*, are made for the use of the paper-hangers, gilders, bookbinders, house-painters in distemper, and many other trades, by boiling down in water the clippings of parchment, glove-leather, fish-skin, and many other kinds of skin and animal membrane. These are used either alone, or mixed with vegetable tenacious substances, such as flour-paste, gum-arabic and tragacanth, and the like. The preparation of these jellies is perfectly simple; the substance used (parchment shreds for example) being simply dissolved in water by boiling, strained and evaporated to a due consistence. Eel-skins and the skins of other fishes, make a cement which is much valued for its transparency and tenacity. The only species of gelatin of this kind, used in the arts, which requires further notice, is

A glue, or cement, that will hold against fire and water, it is said, may be made thus: Mix a handful of quick lime, with four ounces of linseed oil, and let the mixture dry. When it is to be used, dissolve it in water over the fire.

Isinglass.

This is a thin, flexible, tough, whitish membrane, in the form of irregular shreds or clippings, loosely coiled up, and of different degrees of fineness and flexibility, which is procured from several parts of the entrails of several fishes, with scarcely any other artificial preparation than that of extracting, cleansing, and drying.

The finest kind of isinglass is that which has the longest staple as it is called, and which is the thinnest and most flexible. The preparation of isinglass is almost peculiar to Russia, and is made in all places on the vast rivers of this mighty empire, where the large sturgeon and other fishes of this genus are caught, as on the Dnieper, the Don towards the Caspian Sea, the Volga, Oby, Irtish, and other Asiatico-Russian rivers. The best isinglass is that which is prepared from the sturgeon. The membranes which, when dried, form isinglass, are various extensions and processes of the peritoneum,

but more particularly the air-bladder, or sounds, which are very large in these fishes. The sounds when taken out of the fish are first washed with cold water, and exposed a little to stiffen in the air. The outer skin is then peeled off and thrown away. The remainder is simply cut out and loosely twisted into rolls, according to the intended size of the staple, which are pegged down on boards, and hung up on lines to dry. No other preparation is used. An inferior kind of cake-isinglass is made, by taking all the clean shreds of the twisted sort, putting them in a flat metal-pan, with a very little water, and heating just enough to make a cohering mass. This is afterwards dried. It would be tedious to enumerate the minute varieties of isinglass or fish gelatin.

In the following account of the manufacture of isinglass published by Humphrey Jackson, Esq. in the 63d volume of the Philosophical Transactions, he says: If what is commercially called long or short staple isinglass be steeped a few hours in fair cold water, the entwisted membranes will expand, and reassume their original beautiful hue, and by a dexterous address may be perfectly unfolded. By this operation, we find that isinglass is nothing more than certain membraneous parts of fishes, divested of their native mucosity, rolled and twisted into the form above mentioned, and dried in open air"

The sounds, or air bladders of fresh-water fish in general, are preferred for this purpose, as being the most transparent, flexible, delicate substances. These constitute the finest sorts of Isinglass; those called book and ordinary staple, are made of the intestines, and probably of the peritonæum of the fish. The belluga yields the greatest quantity, as being the largest and most plentiful fish in the Muscovy rivers; but the sounds of all fresh-water fish yield, more or less fine isinglass, particularly the smaller sorts, found in prodigious quantities in the Caspian sea, and several hundred miles beyond Astracan, in the Wolga, Yaik, Don, and even as far as Siberia.

Isinglass receives its different shapes in the following manner.

The parts of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy sordes, divested of every thin membrane which envelopes the sound, and then exposed to stiffen a little in the air. In this state they are formed into rolls about the thickness of a finger, and in length according to the size of the intended staple. A thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll are turned inwards. The due dimensions being thus obtained, the two ends of what is called *short staple* are pinned together, with a small wooden peg; the middle of the roll is then pressed downwards, which gives it the resemblance of a heart-shape; and thus it is laid on boards, or hung up in the air to dry.

The sounds which compose the *long staple* are longer than the former; but the operator lengthens this sort at pleasure, by interfolding the ends of one or more pieces of the sounds with each other. The extremities are fastened with a peg, as the former; but the middle part is bent more considerably downwards; and in order to preserve the shape of the three obtuse angles thus formed, a piece of round stick is fastened in each angle. In this state it is permitted to dry, long enough to retain its form, when the pegs and sticks are taken out, and the drying compleated.

The membranes of the book sort being thick and refractory, will not admit a similar formation; the pieces therefore, after their sides are folded inwardly, are bent in the centre, in such manner, that the opposite sides resemble the cover of a book, from whence its name.

That called *cake isinglass* is formed of the bits and fragments of the staple sorts, put into a flat metalline pan with a very little water, and heated just enough to make the parts cohere like a pancake when it is dried.

The manufacture of isinglass has been attempted in the United States from sundry fish and particularly the sturgeon; but little success has attended it. The specimens produced are equal to the foreign.

Isinglass is chiefly used for clarifying wine, malt liquors, cyder, coffee, &c.

Good isinglass is esteemed the finest and purest specimen of animal gelatin. It is entirely without taste or smell; when soaked in water it swells, softens, and if held up to the light is agreeably opalescent to the eye. It readily and totally dissolves in warm water, forming the clearest and most colourless of all the known jellies. The finer sorts are much too valuable to be used for the ordinary purposes of a size or cement, but are principally employed in confectionary, in clarifying wines, and other purposes of the table.

When the jelly of isinglass is much concentrated by evaporation, it forms a delicate cement for joining glass, &c. for

which its great transparency and freedom from colour render it highly valuable. The coarser sort of fish-glue cake, or that which consists of refuse bits of isinglass, brought to a cohering mass by water, is often used for the same purposes as common glue. This, when foul and blackened, is bleached by exposure to the vapour of sulphur, which, on account of the loose fibrous texture, is able to penetrate it sufficiently, an effect which could not take place with the solid cakes of common glue.

GEMS, artificial. See Glass, coloured.

GENEVA. See Gin.

GILDING, art of. The art of gilding or of laying a thin superficial coating of gold on wood, metal and other substances has been long practised, and highly esteemed, both for its utility and the splendid effect which it produces. Gold, from the extreme beauty of its colour, and from the length of time during which it may be exposed to the action of the air without tarnishing, is perhaps the most valuable of all substances for the purpose of decoration; but on account of its dearness and weight it can very seldom be employed in substance, and its ornamental use would be limited indeed, if it was not at the same time the most extensible of all substances: so that a given weight of gold, notwithstanding its high specific gravity, may, by beating, be made to cover a larger surface than an equal quantity of any other body. Among the ancients, the Romans, and among the moderns, the French, have been remarkable for their large and profuse consumption of gold: not only the temples, theatres, and other public buildings being adorned with gilding, but even the private houses of the wealthier classes.

The materials of gilding, or rather the different states in which gold is used for this purpose, are the following: leaf-gold, of different thicknesses and formed either of the pure metal, or of an alloy of this with silver, amalgam of gold, and gold powder. The leaf-gold is procured by the gilder from the gold-beater, for an account of which we shall refer the reader to the article Gold; but the other two substances being prepared by the gilder himself may be with propriety described here. The amalgam of gold is made by heating, in a clean crucible, some pure quicksilver, and when it is nearly boiling adding to it about a sixth of its weight of fine gold in thin plates heated red hot; the mixture, after being kept hot for a few minutes, becomes of a perfectly homogeneous consistence, and may then be allowed to cool: when cold it is to be put in a piece of soft leather, and by gradual pressure, the fluid part of the amalgam, consisting almost wholly of mercury, may be forced through the pores of the leather, while the gold combined with about twice its weight of mercury will remain behind, forming a yellowish silvery mass of the consistence of soft butter. This, after being bruised in a mortar, or shaken in a strong vial with repeated portions of salt and water, till the water ceases to be fouled by it, is fit for use, and may be kept for any length of time without injury in a corked vial. It is of essential importance that the materials of this amalgam, and especially the mercury, should be perfectly pure, as the least portion of lead or bismuth would very materially injure the beauty of the gilding by deteriorating the colour of the gold and filling it with black specks; on this account no mercury ought to be employed that has not been procured from distillation of the red precipitate (nitrous red oxyd of mercury) either alone or mixed with a little charcoal powder.

Gold powder is prepared in three different ways. The first and simplest is to put into a glass or earthen mortar some gold-leaf with a little honey or thick gum-water, and grind the mixture for a considerable time, till the gold is reduced to extremely minute fragments; when this is done, a little warm water will wash out the honey or gum, leaving the gold behind in a flaky pulverulent state. A less tedious and more effectual way of comminuting the gold is to dissolve it in nitro-muriatic acid and then precipitate it by a piece of copper: the precipitate after being digested in distilled vinegar and then well washed in water and dried, is in the form of a very fine powder, and both works better and is easier to burnish than the ground leaf-gold. The finest ground gold however is produced by heating very gradually the gold-amalgam in an open earthen vessel, and continuing the fire till the whole of the mercury is evaporated, taking care that the amalgam shall be constantly stirred with a glass rod or tobacco-pipe, in order to prevent the particles of gold from adhering as the mercury flies off. When the mercury is compleatly evaporated, the residual gold being then ground in a Wedgewood ware mortar with a little water, and afterwards dried, is fit for use.

Gilding is performed either with or without the application of heat. By the first of these methods those substances are gilt which are not liable to alteration by exposure to a moderate heat, such as

metals and sometimes glass and porcelain: the second method is practised with those substances, such as wood, paper, leather, silk, lacquered and japanned ware, &c. which would be injured, and even destroyed at the temperature requisite for gilding the former. The last of these methods, being the simplest, shall be first described; and we shall begin with the art of gilding on wood.

There are two methods of gilding on wood, namely, oil-gilding and burnished gilding. Oil-gilding is thus performed. The wood must first be covered or primed with two or three coatings of boiled linseed-oil and white-lead, in order to fill up the pores and conceal the irregularities of the surface occasioned by the veins in the wood. When the priming is quite dry, a thin coat of gold-size must be laid on. This is prepared by grinding together some strongly calcined red ochre with the thickest drying oil that can be procured, and the older the better: that it may work freely, it is to be mixed, previously to being used, with a little oil of turpentine, till it is brought to a proper consistence. If the gold-size is good it will be sufficiently dry in twelve hours, more or less, to allow the artist to proceed to the last part of the process, which is the application of the gold For this purpose a leaf of gold is spread on the cushion (formed by a few folds of flannel secured on a piece of wood about eight inches square by a tight covering of leather) and is cut into strips of a proper size, by a blunt pallet-knife; each strip being then taken up on the point of a fine brush is applied to the part intended to be gilded, and is then gently pressed down by a ball of soft cotton; the gold immediately adheres to the sticky surface of the size, and after a few minutes the dexterous application of a large camel's-hair brush sweeps away the loose particles of the gold-leaf without disturbing the rest. In a day or two the size will be compleatly dried, and the operation is finished. The advantages of this method of gilding are that it is very simple, very durable, not readily injured by changes of weather even when exposed to the open air, and when soiled it may be cleaned by a little warm water and a soft brush: its disadvantage is that it cannot be burnished, and therefore wants the high lustre produced by the next method. Its chief employment is in out-door work.

If wood be covered with two coats of parchment size, (see GELATIN,) and, when dry, one coat of a black compound of asphaltum, boiled in turpentine, in three hours after, you may gild.

Burnished gilding, or gilding in distemper, is thus performed. The surface to be gilt must first be carefully covered with strong size made by boiling down pieces of white leather, or clippings of parchment, till they are reduced to a stiff jelly; this coating being dried, eight or ten more must be applied, consisting of the same size mixed with fine Paris plaster, or washed chalk; when a sufficient number of layers have been put on, varying according to the nature of the work, and the whole is become quite dry, a moderately thick layer must be applied, composed of size and bole, or yellow ochre: while this last is yet moist the gold leaf is to be put on in the usual manner; it will immediately adhere on being pressed with the cotton ball, and before the size is become perfectly dry those parts which are intended to be the most brilliant are to be carefully burnished with an agate or dog's tooth. In order to save the labour of burnishing, it is a common but bad practice, slightly to burnish the brilliant parts, and to deaden the rest by drawing over them a brush dipped in size: the required contrast between the polished and unpolished gold is indeed thus obtained, but the general effect is greatly inferior to that produced in the regular way, and the smallest drop of water falling on the sized part occasions a stain. This kind of gilding can only be applied on in-door work, as rain, and even a considerable degree of dampness will cause the gold to peel off. When dirty, it may be cleaned with a soft brush and hot spirit of wine, or oil of turpentine. It is chiefly used on picture frames, mouldings, and stucco.

Letters written on vellum or paper are gilded in three ways: in the first, a little size is mixed with the ink, and the letters are written as usual; when they are dry, a slight degree of stickiness is produced by breathing on them, upon which the gold leaf is immediately applied, and by a little pressure may be made to adhere with sufficient firmness: in the second method, some white lead or chalk is ground up with strong size, and the letters are made with this by means of a brush: when the mixture is almost dry the gold leaf may be laid on and afterwards burnished: the last method is to mix up some gold powder with size, and make the letters of this by means of a brush. The edges of the leaves of books are gilded, while in the binder's press, by first applying a composition formed of four parts of Armenian bole and one of sugar-candy ground together to a proper

consistence, and laying it on by a brush with white of egg: this coating when nearly dry is smoothed by the burnisher, it is then slightly moistened with clean water, and the gold leaf applied and afterwards burnished. In order to impress the gilt figures on the leather covers of books, the leather is first dusted over with very fine powdered rosin or mastich, then the iron tool by which the figure is made is moderately heated, and pressed down upon a piece of leaf-gold, which slightly adheres to it, being then immediately applied to the surface of the leather with a certain force, the tool at the same time makes an impression, and melts the mastich which lies between the heated iron and the leather; in consequence of this the gold with which the face of the tool is covered is made to adhere to the leather, so that on removing the tool a gilded impression of it remains behind.

Drinking glasses and other utensils of this material are sometimes, especially in Germany, gilt on their edges: this is done in two ways, either by a simple adhesive varnish, or by means of fire. The varnish is prepared by dissolving in drying linseed oil a quantity of gum anime, or still better, of clear amber equal in weight to the oil: a very drying and adhesive varnish is thus prepared, which, being diluted with a proper quantity of oil of turpentine, is to be applied as thin as possible to those parts of the glass which are to be gilded; when this is dry, which will be in about a day, the glass is to be placed by the fire-side, or in a stove till it is so warm as almost to burn the fingers when handled; at this temperature the varnish will become glutinous, and a piece of leaf gold applied in the usual way will immediately adhere; when the gilding is thus put on and before it is grown quite cold it may be burnished, taking care only to interpose a piece of very thin paper between the gold and the burnisher. If the varnish is very good, this is the best method of gilding glass, as the gold is thus fixed on more evenly than in any other way: it often happens however, when the varnish is but indifferent, that by repeated washing the gold soon wears off: on this account the practice of burning in is sometimes had recourse to. For this purpose some powder-gold is tempered with gum-water and borax, and in this state applied to the clean surface of the glass with a fine camel's hair pencil: when quite dry the glass is put into a stove heated to about the temperature of an annealing oven, the gum burns off, and the borax, by vitrifying, cements the gold with great firmness to the glass; after which it may be burnished. The gilding upon porcelain is in like manner fixed by fire and borax; and this kind of ware being neither transparent nor liable to soften, and thus injure its form in a low red heat, is free from the risk and injury that the finer and more fusible kinds of glass are apt to sustain from such treatment.

All the methods of gilding hitherto described resemble each other by being accomplished by means of some adhesive medium; this, however, is not the case with gilding upon metals; the gold is brought into immediate contact with the other metal, and they both remain firmly united merely by the attraction of adhesion subsisting between them. The simplest of all the kinds of gilding on metal, and which strikingly demonstrates the power of the affinity of adhesion, is one that is sometimes practised on plane surfaces of copper and iron with considerable success. The metal being previously polished and quite clean, is heated to about the temperature of melted lead, and covered with a double layer of gold leaf: by the cautious application of a blood stone burnisher applied gently at first, and increasing the force of the pressure by degrees, the surfaces of gold and copper are brought to touch each other in almost every point, and then adhere with a force proportioned to the completeness of the contact. The first layer being thus burnished down, a second is made to adhere in the same manner, and sometimes a third, if the gilding is intended to be very solid. The objection to this method of gilding is its tediousness, and the almost impossibility of using a sufficient pressure without injuring the evenness of the gilded surface: where these objections do not apply, there cannot be a more effectual mode of gilding, as is evident from the manufacture of gilt silver or copper wire. The bar, before it is committed to the wire-drawer, is plated with gold, by having several leaves of gold successively burnished down upon it, and being then subjected to the strong compression that takes place in wire-drawing, the gold and the other metal become so perfectly united, as to form in a manner but one substance.

The most usual method of covering the surface of a metal with gold is by means of an amalgam, or as it is technically called, *water-gilding*. If the metal to be gilt is silver, the best way of proceeding is first to soak it in warm dilute muriatic acid, that the surface may be rendered perfectly clean; it must then be washed in clean water, changed two or three

times to get rid of the whole of the acid: being afterwards dried and made moderately warm, a little gold-amalgam also warm, is to be carefully and evenly spread upon the silver, to which it will immediately adhere: when this is completed, the piece is placed upon a convenient support over a clear charcoal fire, and while the mercury is evaporating, if any specks or places appear that have escaped the amalgam, a small piece is to be laid on and spread with a brush to supply the deficiency, without removing the article from the fire. After a time the whole of the mercury will be driven off, and the piece after cooling being accurately examined will be found to be entirely covered with a thin coating of pale dull gold. The small roughnesses and loosely adhering particles are now to be removed with a scratch brush, which is made of some exceedingly fine brass-wire bound together into a tuft; by this the surface is rendered perfectly smooth and bright, but it still remains of a pale yellow colour: this defect is next removed by warming the piece and smearing it over with gilder's wax, a composition of beeswax, red ochre, verdigris, and green vitriol or alum. The wax being burnt off over a charcoal fire, and the piece quenched in urine, the colour of the gilding will be found to be much heightened; if it is not sufficiently so by the first application a succeeding one will complete the desired effect; after which the work may be burnished or not, according to the taste of the artist. Instead of the common gilder's wax a mixture of equal parts of nitre, sal ammoniac, green vitriol, and verdigris moistened with water, will answer the purpose.

Copper and the alloys formed by its combination with zinc are gilded nearly in the same way as silver: but as their affinity for mercury is considerably less than that of silver, it would be difficult to make the amalgam of gold adhere to the burnished surface of these metals by the same means, and with the same evenness as takes place in the case just described. To obviate this inconvenience, advantage is very ingeniously taken of the action of nitric acid to facilitate the adhesion of the copper and mercury in the following manner. The piece of copper, a button for example, is first cleaned by steeping in acid and subsequent washing, and is then burnished either in a lathe, or by any other means: after this it is dipped in a neutralized solution of nitrate of mercury, and in the space of a few seconds, owing to the strong affinity of nitric acid for copper, the mercurial salt is decomposed, the copper takes the place of the mercury, and at the same time the mercury is deposited in the metallic state on the surface of the copper, covering it entirely, and strongly adhering to it. The gold amalgam is now applied, and the rest of the process goes on as already described. By this method of proceeding, a given quantity of gold may be made to cover a larger surface than in any other way of gilding on metals: five grains of gold will completely gild both the upper and under surfaces of 144 copper buttons, each of them an inch in diameter.

There is no metal, the gilding of which presents so many difficulties as iron, or rather steel. If the method of simply burnishing down is had recourse to, the heat requisite for this purpose will, in many cases, bring the temper of the steel too low: on such occasions, the way already described of gilding copper is sometimes practised; that is, the parts of the steel to be gilded are pencilled over with nitrat of mercury, by which they are covered with a slightly adhering coating of mercury, then the amalgam is applied, and the gilding finished in the usual way. The objections to this mode of proceeding are first that a considerable heat is required, though inferior to that requisite for burnishing down, and secondly, that even with all possible care the gilding is apt to be rough and scale off. A very considerable improvement on this method is to trace the figure of the gilding on the steel, first of all with a brush charged with a strong solution of sulphated copper, in consequence of which a pretty thick plate of this metal is deposited on the steel, to which it may be made to adhere with considerable firmness by means of the burnisher: thus the gilding is, in fact, performed upon the copper.

A new method of gold gilding upon steel has lately been published, possessed of many advantages over the others, and which probably in time may attain a very high degree of perfection. It depends upon the well known fact, that if sulphuric ether and nitro-muriat of gold are mixed together, the ether will by degrees separate from the acid nearly the whole of the gold, and retain it for some time in solution in nearly a metallic state. If ether thus charged with gold is spread, by means of a pen or fine brush on the surface of highly polished steel, the ether evaporates, leaving the gold behind in close contact with the steel, and the adhesion is considerably improved by the subsequent application of the burnisher. The dearness, and especially the rapid volatility of ether are objections of some

moment, but may be got over by using the best oil of turpentine instead of the ether, which has nearly the same efficacy in decomposing the nitro-muriat of gold, and is both cheaper and not so very quickly evaporable.

Cold gilding upon silver is, we believe, at present entirely disused. It was performed in the following manner. A saturated solution of gold in nitro-muriatic acid was poured upon some linen rags, and when they were become dry, they were heaped in a plate and touched with a hot coal. The fire gradually spread through the mass and reduced it to a heavy black ash. A soft cork being moistened in water was dipped in this ash, to which a part of it adhered, and was then rubbed on the surface of polished silver, upon which the minute particles of gold became fixed, and covered it with an extremely thin coating, which, when burnished, exhibited the genuine colour and lustre of this precious metal.

We have seen, therefore, that the real application of gold as a covering may be performed, either by a metallic mixture after the manner of a pigment; or by friction, upon the same principle as black lead and coloured chalks are used; or by the chemical precipitation of gold from mercury, or some other fit solvent; or, lastly, by glueing or fastening extremely thin leaves of gold to the surface intended to be gilded.

2nd. That the gold prepared for painting is called shell-gold or gold-powder.

3rd. That for cold gilding by friction, a fine linen rag is steeped in a saturated solution of gold, till it has entirely imbibed the liquor; this rag is then dried over a fire, and afterward burned to tinder.

4th. That the chemical application of gold to the surface of metals is usually called water-gilding.

5th. That for the method called Grecian gilding, equal parts of sal ammoniac and corrosive sublimate are dissolved in nitric acid, and a solution of gold is made in this menstruum; upon this the solution is somewhat concentrated, and applied to the surface of silver, which becomes quite black; but, on being exposed to a red heat, it assumes the appearance of gilding.

6th. That the method of gilding silver, brass, or copper, by an amalgam, is with eight parts of mercury, and one of gold, are incorporated together by heating them in a crucible. As soon as the gold is perfectly dissolved, the mixture is poured into cold water, and is then ready for use.

7th. That the gilding of iron by mere heat is performed by cleaning and polishing its surface, and then heating it till it has acquired a blue colour.

8th. The gilding of buttons is done in the following way: When the buttons, which are of copper, are made, they are dipped into dilute nitric acid to clean them, and then burnished with a hard black stone. They are then put in a nitric solution of mercury, and stirred about with a brush, till they are quite white. An amalgam of gold and mercury is then put into an earthen vessel with a small quantity of dilute nitric acid, and in this mixture the buttons are stirred, till the gold attaches to their surface. They are then heated over the fire, till the mercury begins to run, when they are thrown into a large cap made of coarse wool and goat's hair, and in this they are stirred about with a brush. The mercury is then volatilized by heating over the fire in a pan, to the loss of the article, and injury of the workmen's health; though the greater part might be recovered, with less injury to the operators. By an act of the British parliament, a gross of buttons, of an inch diameter, are required to have five grains of gold on them; but many are deficient even of this small quantity.

9th. The gilt trinkets that are now common in the shops, are said to be made of copper coated with brass by an amalgam of one part zinc and twelve mercury, put into muriatic acid with some argal. In this the copper, previously cleaned with nitric acid is boiled. If a little gold be added to the amalgam, the effect is improved; but this is not always done. Copper thus coated may be drawn out to the fineness of a hair.

10th. That painting with gold upon porcelain or glass is done with the powder of gold, which remains behind after distilling the aqua regia from a solution of that metal. It is laid on with borax and gum-water, burned in, and polished. The gilding of glass is commonly effected by covering the part with a solution of borax, and applying gold leaf upon it, which is afterward fixed by burning.

11th. That the gilders of wood, and other compositions designed to supply the place of carved work, make use of two methods: the one called oil-gilding, or gilding in oil, because the gold is made to adhere by means of an oily composition; the other is sometimes called water-gilding, though seldom, but more frequently burnished gold, on account of the burnish it is capable of, which is one of the principal advantages it possesses over the other method.

12th. That the method of gilding in

burnished gold consists in covering the work with parchment size and whiting, thinly laid on at five or six different times. This is covered with a yellow size made of Armenian bole, a little wax, and some parchment size; but in this, as in most other compositions used in the arts, there are variations which depend on the skill or the caprice of the artists.

13th. That the edges of the leaves of books are gilded by applying a composition of one part Armenian bole, and one quarter of a part of sugarcandy, ground together with white of eggs.

Lastly, that leather is gilded either with leaf-brass or silver, but most commonly by the latter, in which case a gold coloured varnish is laid over the metal. Tin-foil may be used instead of silver-leaf for this less perfect gilding, upon such works as do not possess flexibility.

Gilding powder, preparation of,
Gilding on wood,
Gilding in oil,
Gilding in distemper,
Gilding of letters, on vellum or paper.
Gilding on leather,
Gilding on glass,
Gilding on metal, in general,
Gilding, water,
Gilding of steel,
Gilding on silver,
Gilding, cold,
Gilding Grecian,
Gilding of brass,
Gilding of copper,
Gilding of buttons,
Gilding of trinkets,
See Gilding.

Gilding lacquer, or *Gold lacquer*.—See *Lacquer* and *Varnish*.

GIN, *Geneva*, *Holland*—This spirit, which takes the name of gin, is prepared by distilling malt liquor a second time, with the addition of juniper berries. Spirit thus obtained, is merely a solution or impregnation of the essential oil of the berry in the liquor. Instead of using the berry, the essential oil, called the oil of juniper, is merely added, which may be afterwards distilled. The practice of sophisticating liquor with spirit of turpentine, in imitation of gin, has been carried to a great length. Whatever may be said respecting the preparation of this liquor, we may add, that few possess the art or secret of manufacturing the genuine Hollands, as the sellers term it.

We are told, however, upon good authority, that the *common* gin is prepared by distilling two ounces of oil of turpentine, and three handsful of salt, mixed with ten gallons of ordinary malt spirits. To make the best kind, the distillers take three pounds of juniper berries, ten gallons of proof spirit, and four gallons of water, and draw it off by a gentle fire.

The best Geneva, called Hollands Geneva, is imported from Holland, and is chiefly manufactured at Schiedam, a village near Rotterdam. It is supposed they use the same ingredients as prescribed in the last mentioned recipe; only instead of malt spirits, they use French brandies.

They have also manufactories of Geneva, at Ostend, Antwerp, and other parts of Flanders and Brabant; but the Geneva of these countries is greatly inferior to that coming from Rotterdam, and worth nearly one third less in this market.

Notwithstanding the many attempts, which have been made in this country, to manufacture gin equal to the Rotterdam, yet no precise imitation has yet been effected; though at the same time we are of opinion, that a set of experiments with different substances, and the materials of the best kind, conducted with care and precision, would be attended with success. We are inclined to believe, that the age, and proof of the liquor has a considerable tendency to improve the flavour and taste of gin. The use of sweet spirit of nitre, in addition to the oil or berry of juniper has been recommended. This no doubt will improve the flavour, and make the liquor more diuretic.

GIN, commonly called a JINNY, is a machine to free cotton from seeds. Some machines go by water or horses, and some by hand. The gin used in South Carolina differs from the common feet gins, in having iron instead of wooden rollers, and is said to gin 65 lbs. of cotton per day. An improved gin was lately invented by Messrs. Carr and Hancock of Philadelphia, which is said to be superior to the common kind. A figure of the Carolina gin is given by Dr. Mease, in his edition of the Domestic Encyclopedia.

GLASS.—The vitriform state is that of an incombustible body, which has been fused by a red heat. A numerous set of experiments have been made on the vitrification of earths alone, or by metallic oxyds, either performed or confirmed by Kirwan, Achard, Klaproth, Moveau and Wedgewood; and also on the vitrification of earths with saline bodies, which have led to results of much importance in the manufacture of glass. See GLASS-MAKING.

GLASS-MAKING.—In order to com-

prehend the different subjects embraced under the head of glass-making, we shall first enumerate the materials used in the formation of glass; secondly, treat of the glass furnace and pots; thirdly, of the furnace and working of glass; and, fourthly, of the different kinds of glass. After which we will notice the coloured and opake glasses. We trust, that however long the articles may appear to the general reader, the importance of the art, as an item of industry and improvement in the catalogue of American manufactures, will be a sufficient apology.

When, or by whom, the art of making glass was first found out, is uncertain: some will have it invented before the flood; but without any proof. Neri traces the antiquity of this art as far back as the time of Job: but Dr Merret will have it as ancient as either pottery, or the making of bricks; because that a kiln of bricks can scarce be burnt, or a batch of pottery be made, but some of the bricks and the ware will be at least superficially turned to glass; so that it must have been known at the building of Babel, and as long before as the making of bricks was used. It must have been known consequently among the Egyptians, when the Israelites were employed by them in making bricks. Of this kind, no doubt, was that fossil glass mentioned by Ferrant. Imperat. to be found under ground where great fires had been. The Egyptians indeed boast, that this art was taught them by the great Hermes. Aristophanes, Aristotle, Alexander Aphrodisæus, Lucretius, and John the divine, put us out of all doubts that glass was used in their days.

Glass invariably contains two essential ingredients, silex, and an alkali, either potash or soda, and these are all that are absolutely necessary for its composition, but other accessory substances are also used for particular purposes, among which may be particularly mentioned, lime in the form of chalk, borax, oxyd of lead, oxyd of manganese, white oxyd of arsenic and nitre. Each of these requires some separate notice.

The Silex may be obtained from various sources, and of different degrees of purity, according to the fineness of the glass required. The siliceous material almost universally used, is sea sand, which is well known to consist of minute rounded grains of quartz, and is already sufficiently small to be used without any other preparation than that of washing. Another equally pure kind of silex, is the common black gun-flints, which before using, must be heated red-hot, and immediately quenched in cold water. The heat whitens them, and the water splits them in every direction, by which means they may afterwards be ground in mills without much difficulty. But this ground flint though largely used in the potteries in Great Britain, is scarcely ever employed in glass-making. The rounded lumps of white quartz found so abundantly in the beds of rivers in many mountainous districts, are sometimes used in foreign countries for this purpose, being first heated and ground to powder.

In the different kinds of siliceous or *flinty stones*, the United States abound.

The alkali used in this manufacture, is either soda or potash, each being apparently equally well fitted for the purpose. It is always used at first in the state of carbonat, though the carbonic acid flies off in the process; for, glass is a compound of silex and alkali, and not alkaline carbonat. These alkalies are used in every degree of purity, according to the required quality of the glass. For the finest flint-glass, the best pearl ashes, purified by solution and evaporation to dryness are employed; but the inferior glasses are made with the coarser alkalies, with barilla where this alkali is cheap, with common wood ashes, and very largely with kelp. Though these alkalies are very impure, this does not prevent their dissolving the silex into a very good and perfect glass; for the impurities partly consist of neutral salts, and partly of lime and other earths, all of which assist in the vitrification. Glass made from these alkalies, has always more or less of a green tinge, as in the common bottle-glass, owing to the presence of iron contained in these ashes. The methods of purifying and preparing these alkalies, are described under the Carbonats of the respective alkalies.

Lime when employed in glass-making, is generally used in the form of chalk. The property of lime, and the other alkaline earths, in promoting the vitrification of silex, has been already mentioned, and shewn to be very powerful, though less so than that of the alkalies. Lime is used only in small proportions in the glass-pots, for the escape of the carbonic acid from the chalk during the fusion, causes the materials to swell to an inconvenient degree; and also, if the lime is in excess it acts very powerfully on the sides of the pots. Besides, an over proportion renders the glass opake and milky on cooling, though quite clear when hot. Experience has shewn, that to 100 parts of silex, with the requisite quantity of alkali, no more than about 6 or 7 of quick lime can be

added (or chalk in proportion) without endangering the clearness of the glass. The particular use of this ingredient, besides that of affording a very cheap flux, is to render the glass easier to work, and less liable to crack by sudden changes of temperature.

Borax, is perhaps, the most powerful and valuable flux that is known. On account of its high price, it is not used in any of the common glasses, but is employed in the finest kinds of plate glass, and those articles that are required to be particularly clear and free from specks and bubbles. It is peculiarly well fitted for this purpose, as it renders all vitrescent compounds into which it enters remarkably thin-flowing, and therefore best adapted for being cast in a mould, which is the way in which these articles are manufactured. A very small quantity of borax will correct any deficient strength in the alkali.

The oxyds of lead, of which litharge and minium, (red lead) are the only ones employed in the large way, are of singular use in glass-making. Litharge melts by itself into a very dense clear yellow transparent glass, remarkably soft and unctuous to the touch, fusible at a very low red heat, and when melted acting so powerfully on all earthen vessels as to run through the common porous crucibles in a very short time, almost like liquor through a sieve, but vitrifying and corroding the bottom of the crucible in its passage. Litharge is therefore a most powerful flux to all earthy mixtures, and it imparts to glass the valuable qualities of greater density and greater power of refracting the rays of light, and of bearing sudden changes from heat to cold, without being so liable to crack, and also greater tenacity when red-hot, and therefore easier to be worked.

Most of the finer glasses contain a considerable quantity of this oxyd, particularly the London flint glass, or that sort which is used for most of the purposes of the tables, for lustres, and other ornamental works, which when cut into various forms, display so beautiful a play of light, for artificial gems, and for most optical purposes. Glass containing much lead, has, however, the great defect of being extremely soft so as to be readily scratched and injured by almost every hard body it rubs against. It is also extremely fusible, so that thin tubes of it will bend with ease in the flame of a candle, and will sink down into a shapeless mass, at a very moderate red-heat. This quality for chemical purposes, is sometimes an advantage, sometimes the contrary. When the lead is in excess there is also some danger of the glass being corroded by very acrid liquors. Another defect also attending the use of lead, is the extreme difficulty of uniting it so intimately with the silex and alkali, that a whole piece of glass wrought with it, shall be of equal density throughout, as the litharge on account of its much superior density is always liable to sink towards the bottom of the glass-pots before it can be detained by the other ingredients. This inequality subsists throughout, so that every stratum of the melted mass is of intermediate density between the stratum above and that below, which is apt to occasion *waves* in the glass when wrought, such as appear when water is gently poured on sulphuric acid, without mixing, and the vessel slightly agitated. This defect is particularly felt in some optical purposes where a certain thickness of glass is used.

The black oxyd of manganese was used in glass making long before its precise nature was understood. Its ancient name of *glass soap* denotes its particular use, namely, that of clearing the glass from any accidental foulness of colour which it would otherwise contract from the impurity of the alkali, or other materials employed, and especially the green tinge, owing as already mentioned to the presence of iron.

Oxyd of manganese, however, is capable of destroying such colours as are produced principally by coaly matter. It is said to produce a mixed colour with the oxyds in the glass.

The substances which take away the colour from glass tinged red with manganese, which often happens, are all the salts with the basis of sulphuric acid, such as gypsum, sulphat of soda, &c. and also sulphur itself, likewise the oxyds of tin and iron, and of some other metals.

The oxyd of manganese is a very powerful flux for all earthy matters. This is seen in the result of all the attempts to reduce it to a reguline state in the usual way of combining with a saline carbonaceous flux, and heatiug in a naked crucible. Not a particle of the oxyd is reduced in this way, but the crucible constantly runs down, in a heat sufficiently intense for the reduction of manganese, together with all its contents, into a green slag. The only way hitherto known of reducing this oxyd, is to enclose it without any saline or earthy addition in a crucible lined with charcoal, and apply a very intense heat. Manganese as well as lead gives a great density to glass, and also like lead it always settles somewhat to the bottom of the pots where it accumulates, and being here out of the way

of most of the decolouring additions it gives a purple to the glass immediately adhering to the bottom, and partly corrodes the pots; so that when these are worn out and broken up, they are deeply encrusted with a thick purple vitrescent slag easily separable by the hammer.

The oxyd of manganese forms a glass specifically heavier than common glass; whence it arises, that the glass at the bottom of the pots in many glass-works is violet. It is undoubted, that when this happens, the dose of manganese is too great. The usual method of remedying this inconvenience is to stir up the glass with an iron bar, after previously raising the fire to render it more fluid. It is thought, that the manganese is in part dissipated by that means; but it is merely distributed through the mass. A more effectual remedy is to add some combustible substance to the glass to destsoy its colour; such as arsenic, charcoal, sulphur, &c.

The white Oxyd of Arsenic is another flux used pretty largely in glass-making. This substance (as fully mentioned under the article *arsenic*) is volatile in the fire in proportion as it approaches the metallic state, and hence it is of advantage to employ nitre to oxygenate it more highly, and make it more fixed. Its use in correcting the purple red colour of manganese has been just mentioned. Arsenic is a very powerful flux, and very cheap, but must be used only in great moderation, for it takes a longer time to mix intimately with glass, and to allow it to be perfectly clear, than any other of the additions commonly employed. Glasses in which the arsenic is not thoroughly or long enough fused, have a milky hue, which encreases by age: when the arsenic is in excess they tend to deliquescence, gradually become soft, and are decomposed. They are besides unsafe as drinking vessels. The arsenic is constantly volatilizing from the arsenical glass when preparing, that is, till it is intimately united with the rest of the glass; after which however it cannot again be separated by heat or any common means.

As arsenic is entirely volatilized when in contact with any carbonaceous matter, another use has been made of it, which is to disperse any such matter which may remain in the glass, owing to a defect in the calcination of the alkali, or any other cause. When this happens, small lumps of white arsenic are sometimes thrust down to the bottom of the glass-pots and stirred in with the contents, and the arsenic meeting with the unburnt carbon diffused through the glass unites with it, is speedily volatilized with it, and the glass is left freed both from the adhering carbon, and also from most of the arsenic that was added. The motion excited through the melting glass by the volatilization of the arsenic is also thought useful in hastening the compleat vitrification of the ingredients.

Nitre is used in glass-making only in small quantities, and is an accessory ingredient to fulfil particular purposes. This salt, at a heat even much below that of the glass-pots is readily decomposed, giving out much oxygen, nitrous gas and azot, and leaving behind its pure pot-ash. It is of service in destroying any carbonaceous matter in the ingredients of the glass (with which it should be mixed before fusion) and its use in fixing arsenic, and in keeping up the tinging power of manganese has been already mentioned. The same circumstance of keeping metallic oxyds up to their highest state of oxygenation, also renders this salt often useful, and even necessary in the preparation of some others of the coloured glasses.

Of the Proportion of Silex to the Saline fluxes.—The exact proportion and number of ingredients that enter into every species of glass cannot easily be obtained with any certainty, though many apparently good mixtures are given by different authors, which will be afterwards mentioned. But some observations may be made on the solvent power of mere alkali over siliceous earth, which is the basis of the rules for the composition of glass, as, strictly speaking, nothing else is necessary for the formation of glass than a solution of silex in alkali by a melting heat; all the other additions are more properly useful than necessary ingredients.

When silex is melted with twice its weight, or more, of dry carbonated alkali, either potash or soda, the result is a very soft deliquescent vitreous mass, always more or less opake, strongly alkaline to the taste, and which on exposure to moist air, or more speedily if put into water, totally dissolves into a clear liquor which is a solution of silex in alkali. This silicited alkaline solution is decomposed by all the acids, which separate the silex in the form of a white powder.

When the alkali employed (meaning all along in this place the dry carbonated alkali) only equals the silex in weight, or at least does not much exceed it, the glass is now transparent, but is still soluble in water as before.

It is not till the alkali is diminished to about one half of the weight of the silex

that the glass becomes perfectly hard and insoluble in any corrosive liquors, (the fluoric acid excepted) and in short, acquires the character of a perfect glass.

This proportion therefore, that is two parts of sand to one of alkali is usually the datum on which the doses of the species of alkalies actually used are regulated. Thus if common wood ashes (of which the alkaline part is reckoned at no more than 10 per cent.) are employed, 100 lbs. of these would require no more than about 20 lb. of sand. If the best Spanish barilla, containing from 45 to 50 per cent. of carbonat of soda, be used, an equal weight of sand may be added; but if purified pearlash be taken, it will melt down perfectly twice its own weight of sand.

But glasses composed merely of pure alkali and sand require a very strong fire for their fusion, and are hard, harsh, and difficult to work. They are therefore never used alone, for even when common ashes and sand are the only ingredients, the ashes contain an abundance of earth and other substances. As one half the weight of the sand is reckoned an abundant allowance of alkali, it follows of course that when litharge, arsenic, borax, or any other fluxes are employed, the quantity of alkali will be proportionally diminished.

It must not be supposed that the glasses themselves contain nearly the original proportion of silex and alkali that was put into the glass-pots. Of these two materials the alkali is abundantly volatile in the intense fire necessary for glass-making, but the silex is absolutely fixed; and hence in proportion to the strength and continuance of the fire, the relative quantities of the two are constantly altering, that of the alkali diminishing, and that of the silex and other ingredients increasing. That the alkali does really volatilize, and very rapidly at first when in large proportion in the mixture, is put beyond a doubt by the dense vapour which always proceeds from the glass-potts when the glass is first heating, and which corrodes the covers of the crucibles, and by various other tests is proved to be part of the alkali escaping. This may partly be owing to a want of thorough mixture of the silex, which, though in grains when sand is used, is very far short of intimate mechanical mixture. No continuance of heat indeed can drive off all the alkali, for when once melted into glass, it must remain as such, but the solvent power of alkali upon silex increases in proportion as the temperature is raised, as occurs in most other cases of solution.

Mr. Loysel has the following remarks on the subject of the volatilization of the alkali, but it is to be wished that he had given more of the particulars of the experiments on which they are founded. If a mixture of two parts of sand and one of alkali be exposed for the accustomed number of hours in the ordinary glass-house fires (about 8000° degrees Reaumur) the glass when finished will contain no more than a fourth part of alkali, all the rest having been dissipated. If the glass be heated so as to retain no more than about 15 or 20 of alkali to 100 of silex, it will be very hard, transparent, and almost equal in beauty to rock crystal. Of a glass originally made of two parts of sand and three of alkali, Mr. Loysel observes, that if kept in the heat of 3000° for one or two days, the result will be a soft glass retaining nearly equal parts of alkali and silex; if further heated to 9000° a solid glass will remain composed of about four parts of silex to one of alkali; and lastly, if urged to a heat of 10 to 12000° the glass will be extremely hard, brilliant, and will consist of no more than three parts of alkali to seven of silex.

All the common alkalies are largely mixed with various neutral salts, particularly common salt, and some of the sulphats. It does not seem entirely ascertained what share these have in the vitrification. It is generally asserted that they are merely inefficient, and act as extraneous bodies, and it is certain, that during the fusion of the glass materials a quantity of scum rises to the top of the pots, which is a very heterogeneous mixture of common salt and other neutral salts and other impurities of the alkali, as will be presently noticed. Common salt being readily volatile in a full red heat, can scarcely be supposed to contract much permanent union with the silex, and yet if a quantity of this salt be inclosed in a well luted crucible and heated without addition, it will readily penetrate the sides of the vessel, and deeply corrode them in its passage.

But the sulphats being fixed in the fire can withstand without volatilization all the heat of the glass-pots, and at this temperature they are decomposed largely by the silex, this earth uniting with the alkali of the sulphat and the acid flying off alone. Thus if three parts of sulphat of soda ond one of silex are put into an earthen retort with a receiver, and the fire strongly urged to whiteness, a trans-

parent glass of silex and soda will remain, and the receiver will contain much sulphureous acid.

This is one of the very frequent examples of chemical affinity being changed by temperature, for at any common heat the sulphuric acid has a much stronger affinity for alkali than this has for silex, and therefore will decompose the solution of silicited alkali, and separate the silex. Of the common neutral salts therefore, the muriats probably add but little to the quantity of real flux, but on the contrary, the sulphats are important additions, and leave in the glass pot the alkali or earth with which they were united. Hence in some places sulphat of soda, where impure, and not reserved for other purposes, is sold to the glass-makers, and found to answer completely. This is the case at Freyberg, where the pyritical ores of silver and copper after roasting are converted into sulphats, from which a large quantity of impure sulphat of soda mixed with some arseniats is obtained, which is used without preparation as the sole flux in glass-making.

Of the Glass Furnaces and Pots.—Glass is made in large deep pots or crucibles closed every where except at one side-opening, and arranged round a kiln or dome-shaped oven, into the middle of which they project, and by which they are entirely enclosed except at the side orifice above-mentioned, which opens into a small recess formed by the alternate projections of the masonry and flues of the kiln in which recess the workmen stand.

The kiln is supported on arches, beneath which is a large space for a brisk and copious draught of cold air from without. The floor of the kiln nearly level with the ground is covered with a grate of very strong iron bars on which the fuel is thrown, and the flame draws very strong and fierce round the pots, and passes out together with the smoke, in one body, through the top of the dome, which is lengthened into a chimney for the space of a few feet. The precise construction of the glass house can only be understood by figures which cannot be given in this place. At the top of the dome between the pots and the chimney, is a kind of broad covered shelf which is heated by the flame in its passage round it, but to a much less degree of intensity than the pots, and serves as a receptacle for the glass as soon as wrought, in which it may cool, slowly and gradually. This is the *annealing oven.*

Very great care is required in building a glass-house, to form the bricks of an earth which combines in the highest degree the qualities of density and infusibility, so as to enable them to withstand the unceasing action of very strong heat for a great length of time, for the fires are seldom suffered to go out from the time the furnace begins to be in action, till the inevitable wear and fusion of the walls renders a repair necessary, which may be in about two or three years. But still greater attention is required in selecting proper materials for the glass-pots, as these have to withstand for a given time not only the constant action of a very fierce fire, but also the solvent power of the glass itself with the variety of powerful fluxes in full vitrification. The pots therefore, being made of earth, must necessarily be themselves always gradually dissolving in their contents, and hence, besides the property of difficult fusibility, an earth of considerable purity is required for these, so that a small admixture with the glass may not injure its quality.

The chief material both of the walls of the furnace and of the pots is clay, as it is of almost every vessel and substance destined to bear a long and violent heat. This is mixed with sand, in different proportions according to its quality, for the fire-bricks and other parts of the furnace. On an average, a fine stiff clay will require about two-thirds as much of sand to bring it to such a consistence that it will work easily, dry in a very compact mass, and resist the impression of fire for a length of time. Still however, this addition of sand renders it in some degree fusible, so that when the fire is in activity, drops of vitrified earth are constantly and slowly falling from the walls, some of which cannot be prevented from dropping into the glass and mixing with it. The crucibles are made of a still more refractory mixture, which consists simply of raw and of burnt clay, the latter is called technically *cement*, and is procured from the remains of the former furnaces when pulled down for reparation. As clay loses its plasticity by baking, it then answers all the purposes of sand in diminishing the tenacity of the mass, and especially in lessening the shrinkage whilst drying, and being the same kind of earth as the unbaked, it adds nothing to the vitrescibility of the material, for as has been already shewn, earthy compounds are, *ceteris paribus*, fusible in proportion to the number of ingredients of which they are composed.

The particular manipulations employed in constructing a glass-furnace and pots

are foreign to the present purpose: very great precaution is used in drying them thoroughly and very gradually. This is peculiarly necessary in making the pots, for as they are intended to hold a considerable weight of glass, and to last many months, they must be made very thick and strong, and therefore would readily crack without much care. When finished, they are first kept in a warm sheltered room for many weeks to dissipate much of their moisture, and the small fissures formed by the unequal shrinking of the clay are closed up by beating gently with a mallet. They are afterwards heated very gradually in a small oven made for this purpose, and are slowly brought to a red heat and kept there the requisite time, after which they are removed, whilst still hot, to the furnace and soldered down to their place by fire clay. A still further shrinkage takes place when in the furnace, for which reason they are let to stand empty for a day or two before they are fitted to receive the materials for glass. These pots last on an average about a year, and hence they must be changed once or twice during the continuance of the furnace itself.

The fuel used in England, is constantly coal, and the best is of the kind that gives a strong steady blaze. As the glass-pots open only outward, none of the fuel or flame comes in contact with their contents, except through any accidental crack in the clay soldering.

Considerable variety prevails respecting the exact form and construction of the furnace and crucibles, in different countries, and also according to the kind of manufacture, and in particular the plate-glass furnace requires a different arrangement.

Of the fusion and working of Glass—The sand, alkali, and other materials for the glass, after mixture, are usually first calcined for a longer or shorter time, by a separate operation, before they are transferred to the glass-pots. This operation is called *fritting*, and is performed either in small furnaces close adjoining to the proper glass furnace and heated by the same fuel after the chief force has been spent upon the glass-pots, or else in small furnaces or ovens constructed for the express purpose. The uses of fritting are, to drive off all moisture from the materials which might endanger the glass-pots, to expel part of the carbonic acid from the alkalies and chalk, and thus to moderate the swelling up in the glass-pots, and especially to cause an adhesion or commencement of chemical union between the alkali and silex, and the metallic oxyds. For if the raw materials were immediately exposed to the intense heat of the glass-pots, the alkali would flow thin like water, and the grosser particles of the sand and the heavier oxyds would fall to the bottom, leaving the alkali above, nearly disengaged, and therefore liable strongly to act on the crucibles, and also a large portion would be rapidly volatilized to mere waste. The glass materials therefore, would thus have an excess of sand from the loss of the alkali, and a portion would remain at the bottom unvitrified.

Fritting should be gradual, and carried to the point of semi-vitrification, in which the materials strongly adhere and begin to become pasty, but are still opake, and not yet homogeneous. It has the further use of destroying any carbonaceoue matter.

When the materials are sufficiently fritted they are thrown into the glass-pots with clean iron shovels through the side opening. The fire is previously raised to its greatest intensity to prevent the whole furnace from being chilled and to save time. As the fritted materials are much more bulky than when they fall into a thin-flowing glass, the pots receive their full charge by two or three successive portions, the last-added being always thoroughly melted down before a fresh charge is thrown in When full, the side opening is closed up with wet clay, except a small hole for examining the work, which closure is pulled down when the glass is well refined, and about to be worked off.

As soon as the frit begins to feel the action of the fire in the glass-pots, which is immediately raised to its greatest pitch, it sinks down into a soft pasty state, which gradually encreases in tenacity till a perfect fusion is effected It is still however opake at first, owing to the rising of a quantity of a white porous scum, the nature of which has engaged much attention, and is known by the name of *sandiver*, or *glass-gall*. This substance appears to be a confused mass, consisting of all those salts, contained in common alkalies, which readily melt at somewhat less than a glass-making heat, and are either naturally, considerably volatile, or have little if any affinity for silex, and do not unite in the composition of glass, but being superficially lighter, rise to the top. There is another heterogenous substance, also called sandiver, which sometimes is found at the bottom of the pots, and is taken out when the whole is worked off. The nature of this is very different from the other, and consists apparently of a vitri-

fied mass of arsenic and earthy impurities. But the scum or proper *glass-gall* is almost entirely saline. When laded out and cooled, it forms a white crumbly mass, sometimes quite white, and at other times brown and fouled, and strongly saline, but not very uniform in its composition, being sometimes merely salt, often very bitter, probably as common salt or sulphat of potash predominate. Glass-gall is very volatile in a strong fire, so that it is constantly dispersing from off the surface of the glass in a dense vapour, at first thick and black, afterwards whiter, which very powerfully corrodes the top of the crucible in its passage. If the fusion were continued long enough, the whole would be dispersed merely in this way; but it is generally scummed off with iron ladles, and sold to metal-refiners as a powerful flux. As part of the alkali itself certainly is dissipated by the continuance of fire, partly before it can unite with the silex, partly from the glass itself, much of the corrosion of the pots must be owing to this circumstance, and probably it must also unite in part with the glass-gall, which renders it slightly deliquescent. An abundance of this glass-gall is one of the greatest inconveniences that the glass-maker can meet with, for it requires a considerable time of very strong heat before the whole can be dissipated; or if the glass be wrought before it is thoroughly purged of this material it is full of bubbles, unsound, and has a cloudy gelatinous appearance. Glass made with potash, is more likely to suffer from glass-gall, than the soda glasses; for the potash-glasses are harder and do not run so thin as the others, and the glass-gall arising from them does not so easily dissipate in the fire.

During this part of the process, small samples are occasionally drawn out of the pots with an iron rod, to examine the state of the materials; and, gradually, the glass becomes more and more flexible, dense, and less brittle, and at last the glass-gall is entirely dissipated, and the vapours which it occasioned, are no longer to be perceived. This is the first and very well defined step in the process of glass-melting.

The glass is now full of minute specks or bubbles, which the continuance of the heat causes to expand and burst at the top, till at last it refines beautifully clear, transparent, and colourless, as is seen by the samples, which are, from time to time, taken out and cooled. This second process, namely, from the cessation of the vapour of the glass-gall and its thorough removal, to the time when the glass is perfectly clear and free from bubbles, is called the *refining*. The glass is now compleat, but is of too thin a consistence to be wrought, it is therefore cooled by stopping the draught of the fire round the individual pot, and in cooling, it thickens to the working point. The clay with which the opening was luted is then picked off, and the working begun. But if the glass is to be cast into plates (as all the large mirrors are) a much shorter cooling is required, as for this purpose it is required to flow very thin and hot.

The particular manner of managing the pots, and the alternations of filling and working them off varies considerably, and depends chiefly on the convenience of the manufacturer. Sometimes half the number of pots (which are generally six in common glass-houses) are kept in the working state, whilst the materials are melting or refining in the three others, and sometimes they are all filled together. On an average, it takes about forty-eight hours for the fine flint glasses, from the time that the pots are first filled till the glass is ready for working; but there is no occasion to use it immediately, as it may be allowed to remain a considerable time at a low working heat without any injury.

When the glass is cooled down to the working heat, which is a very full red, it has a kind of consistence and tenacity not exactly to be found in any other substance in nature. It is just soft enough to yield with the greatest ease to any outer impression, even to the force of the breath when urged pretty strongly in the center of the glowing mass, and may be bent, pulled out and shaped in every possible way; and its tenacity is such that it extends uniformly without producing any cracks or fissures; but, when stretched to the utmost, it pulls out to a solid string, the diameter of which is constantly decreasing till it separates from the mass in a thin capillary thread. As it cools it stiffens, and becomes perfectly brittle, which takes place when no longer red hot, and at this time also it becomes transparent. Melted glass adheres very feebly to polished metal, so that it is wrought with bright iron tools with the utmost ease.

Almost every kind of glass vessel, and utensil, common window glass, and in short, almost every manufactured glass article except plate-glass, is shaped out of a hollow globe formed by blowing. The instrument used for this purpose, is simply a hollow iron rod, about four or five feet long, which the workman first dips in the glass-pot and turns about till a sufficient mass of the melted glass ad-

heres to it; he then holds it near the ground, by which the mass pulls out and lengthens by its own weight, and then blows strongly through the tube. The breath thus penetrates the center of the red-hot mass, and immediately extends it into an uniform hollow globe of the required thickness. This must be immediately blown out as large as intended, and the force of the breath kept upon it for a few seconds till it stiffens by cooling, otherwise it would again sink in by the compression of the denser external air. This operation produces a hollow globe, adhering by a neck to the iron rod, and is the original form out of which the others are fashioned.

It would be impossible to give, in a short space, an adequate idea of the ease and simple dexterity by which, with a few instruments, this most beautiful substance is stretched out, enlarged, closed, perforated, and formed by a few ingenious manœuvres into all the common utensils. As a single and short example, the making of a common tumbler may be given. A hollow globe, with a short neck, being first blown on the iron rod as above-mentioned, it is taken off in the following way: an assistant dips the end of a short solid iron rod into the glass-pot, and brings it out with a little of the melted glass adhering, this is immediately thrust against the bottom of the globe, at the part directly opposite the neck, to which it firmly unites, so that the globe becomes cemented upon this second rod by means of the melted glass. The workman then wets a small piece of iron with his mouth and lays it on the neck of the globe which is still extremely hot, and this cracks it quite round in a second or two, so that with a slight pull, it comes off, and detaches the hollow rod, leaving the globe now open at the neck, and transferred to the second rod at the opposite side. The globe being now open, is again softened by holding it a few seconds over the mouth of the glass-pot, and is cut away from the open end to the form of a cup, by iron shears. The workman when fashioning the globe, usually sits upon a kind of arm chair, the arms of which slope forwards, and are covered with a flat, smooth iron plate, and by laying the iron rod straight before him, resting on both the arms of his seat, and twirling it backwards and forwards, the hot glass at the end is made to revolve like clay on a potter's lathe, and thus is opened, widened, or compressed at pleasure, by any simple iron instrument that is pressed against it. The globular cup is thus extended easily into a cylinder, or made barrel-shaped, if this be the required form, and is smoothed up at the edges. It only now requires to be separated from the iron rod, which is done as before, simply by wetting it at the point of attachment, and the tumbler drops off compleat. This last operation leaves that burr or roughness, with sharp fragments, which is seen at the bottom of all glass vessels, unless taken off by grinding.

Another important process is required before the glass vessel is fit for use, which is that of *annealing* or cooling very gradually. All glass articles require annealing except those that are very thin and uniform without joining or burr of any kind. Without this precaution the glass remains always liable to fly by the least change of heat and cold, by the smallest scratch, or even apparently without any external cause. The precise mechanical cause of this disposition to crack in unannealed glass is very difficult to explain, but generally speaking it is supposed to be the forcible contraction of the outer part by sudden cooling, whilst the inner portion is still soft and half-fluid, so that the whole fixes with a permanent strain or inequality of pressure of one part upon the other; and as glass is extremely elastic, though brittle, any force which tears asunder a portion, however small, of the tense part, communicates a strong and sudden impulse over the whole mass. The annealing is generally performed in a hot chamber built for the purpose at the top of the glass-house above the crucibles and a little below the chimney as already mentioned. The heat is here so moderate as not to soften the glass, and the articles are gradually withdrawn to a cooler part till they are cold enough to be taken out for use. Common articles are generally annealed in the course of a day. The place of all others in which ill-annealed glass is most liable to break is at any point of junction where two pieces are cemented together when hot, and as different kinds of glass contract to a different extent, two dissimilar pieces of glass should not be joined together.

The hard glasses, and those in particular made only with alkali and earths require much more annealing than the softer and more fusible glasses into which litharge enters largely.

The extraordinary fragility of unannealed glass is shown in a very striking manner by two kinds of experimental toys made for the purpose, the one is the *Bologna phial*, as it is usually called, and the other the *Rupert's drop*. The Bologna phial is simply a phial of any form whatever, made of any kind of glass, but much

thicker at bottom than at top, and cooled immediately without annealing. These being pretty stout from their thickness will bear a smart blow with a wooden mallet or any blunt instrument, or the concussion of a leaden bullet dropped into it from a considerable height, without injury; but if any sharp body however small, such as a large grain of sand, or better a shiver of a gun-flint be dropped in from only a few inches height, the bottom cracks all round just above the thickest part and drops off. The same effect happens if the bottom be slightly scratched with any hard body. When very brittle, if a hard angular substance such as a cut diamond be dropped in, it sometimes will pass through the bottom, though very thick, with apparently as little resistance as through a spider's web. These glasses, when they have received the first injury, do not always crack immediately, but remain whole sometimes a few minutes, sometimes for hours, and then suddenly give way.

The Rupert's drop is simply a small solid lump of green bottle glass poured when red-hot into water, and therefore is a rounded lump gradually extended into a kind of tail nearly capillary at the extremity. This solid lump will bear very considerable violence on the rounded end without injury, and is altogether extremely tough, but when the least portion of the thin end is broken off, the whole bursts with a smart snap, instantly crumbles into a countless number of fragments as small as fine sand, which from their very minuteness do no other injury to the hand holding it, than a slight stinging from the sudden concussion.

This most singular phenomenon is obviously owing to some permanent and very strong inequality of pressure, for when they are heated so red as to be soft and merely let to cool of themselves, this property of bursting is entirely lost, and at the same time the specific gravity of the drop is encreased.

The peculiar brittleness of the Bologna phial is also removed by again heating and cooling slowly.

A defect in the annealing of common window glass is also shown when cut by the diamond. When the glass is well annealed the diamond cuts it with moderate ease, making an uniform smooth furrow, at first dark, but which gradually opens and then appears as a bright silver thread; but when the glass is badly annealed, the diamond works with much more difficulty, the cut opens very slowly, and often flies into a different direction, or the glass entirely breaks.

The other more common defects of glass are a liability to be acted on by corrosive liquors (which takes place when too much saline flux has been used) and also a number of visible imperfections, some of which materially injure the soundness as well as beauty of the manufactured articles. The chief of these visible defects are *striæ*, *threads*, *tears*, and *knots*. The *striæ* are undulating waves in the glass, perfectly transparent and vitrified, but which produce much strange distortion when used for windows or for optical purposes. This defect arises from the imperfect mixture of the materials, and the great difference in their specific gravities. For the gravity of glass made simply with alkali and sand is about 2·3 or 2·4, that of alkali and crucible clay, about 2·5; that of alkali and chalk 2·7 or 2·8; whilst the vitrified oxyd of manganese alone weighs 3·2 and the glass of lead 7·2 nearly. Therefore when these are altogether melted in the glass-pot, if they are not thoroughly mixed, they are in the case of liquors of unequal density, in contact with each other, and slightly agitated, so as to shake the different materials into streaks or waves.

The defect from this cause is seen very strikingly in ordinary prisms, or pieces of solid glass of a certain thickness, which are seldom quite uniform in density throughout. For very nice purposes it is often of use when small moveable crucibles are used, to invert them when the glass is melted and empty the contents, whereby the heavier parts become mixed with the lighter as they fall through them.

Threads in glass-making are those streaky filaments which arise from the vitrification of the clay. They are generally green and often render the glass more liable to crack at these parts.

Another and one of the worst defects is *tears*, or drops of vitrified clay falling down from the furnace into the pots and entangled with the glass. Articles made of glass with this defect are always very brittle, and generally break of themselves by slight changes of heat and cold. This is the more likely to happen in proportion as the tear is nearer the surface.

Glass when not sufficiently refined by continuance of the melting heat is always full of small bubbles. This fault may also happen from a deficiency of flux which renders the glass less fusible, and therefore stiffer, during the ordinary time and degree of heating, so that the bubbles cannot easily disengage themselves. Hence the soft fusible glasses with much lead are much less liable to this fault than

the hard green bottle glass which is made only of alkali and earth.

Another defect is *knots*, which arise either from a portion of sand that has escaped vitrification and remains entangled in the glass, or from a remaining quantity of glass-gall; or from bits of the crucible which may be accidentally knocked off by the iron instruments used in the working.

Of the different kinds of Glass.—Though an infinite variety is found in the quality and composition of different glasses, there are some principal kinds made for totally distinct purposes which may be shortly noticed.

The *flint glass* of London and other parts of England (called by foreigners *crystal*) is that beautiful, soft, brilliant, fine glass of which both the common and finest articles of white glass in domestic or ornamental use are manufactured. Many optical instruments are also made of the same material. It is particularly distinguished for the quantity of litharge which enters into its composition, on which account it is by far the heaviest, the most brilliant, the softest, and the easiest to work, and also the most expensive.

The precise proportions of ingredients are not usually known, but the following is said to make an article of the best quality, namely; 120 parts of fine clean white sand, 40 of pearlash well purified, 35 of litharge or else minium, 13 of nitre, and a small quantity of black oxyd of manganese. The distinct use of these ingredients has been already explained. Very different proportions will also produce a fine glass of similar quality, and in particular, the quantity of lead may be much encreased which naturally gives a yellow tinge but which the manganese counteracts. The following composition for a fine crystal glass is given by Loysel: 100 pounds of white sand, 80 to 85 of red oxyd of lead, 35 to 40 of pearlash, 2 to 3 of nitre; and one ounce of manganese. The specific gravity of this glass and of the common London flint glass is about 3·2.

The oxyd of lead is so abundant in this glass that it may be partially reduced in a very curious manner. If a tube of it be made red-hot and hydrogen gas passed through, the whole inner surface becomes covered with a half-brilliant black coating owing to the reduced lead, and moisture appears at the further end. This was discovered by Dr. Priestley.

Crown-glass is the name given to the best sort of window glass, the composition of which varies considerably, but it differs essentially from the last in containing no lead nor any metallic oxyd except manganese and sometimes oxyd of cobalt in minute doses, for the sole purpose of correcting the natural colour and not as a flux. This kind of glass therefore is much harder and harsher to the touch than the flint glass, but when well made is a very beautiful and perfect article. The composition is sand, alkali, either potash or soda, the vegetable ashes that contain the alkali, and generally a small portion of lime. A small dose of arsenic is often added to facilitate the fusion. Zaffre or the oxyd of cobalt with ground flint is often used to correct the dingy yellow which the inferior kind of crown-glass naturally acquires, and by adding the blue, natural to glass coloured with the oxyd, to convert the whole into a soft light green. The green hue thus given is very slight and not disagreeable to the eye, and is hardly perceived unless the light pass through a great thickness of glass, as happens when a piece is held up edgeways. The quantity of zaffre necessary for this effect is extremely small, one ounce being sufficient for 1000 pounds, so that it is only $\frac{1}{16000}$ of the whole. It need hardly be added that when the sand, alkali, and lime, are very fine, and only these ingredients are used, no zaffre or corrective of bad colour is required. A great quantity of fragments and refuse pieces of glass is always collected during the working, and these are added again to the next fusion, but as glass always loses alkali by the long continuance of fire and becomes thereby harsher and less fusible, too great a portion of these refuse bits (which of course undergo twice as long a fusion as the raw materials) will very sensibly alter the quality of the glass. As however they consist of glass already refined, the pot which contains much of them is much sooner brought to a working state, as it contains less glass-gall and impurities. These fragments of glass are reduced to gross powder by being heated red-hot, and immediately plunged into cold water, which splits them in every direction and enables them to be readily broken down. They should not constitute much more than a third of the whole composition. A very fine glass of this kind may be made by 200 parts of pretty good soda, 300 of fine sand, 33 of lime, and from 250 to 300 of the ground fragments of glass.

The manufacture of the common window glass though made by blowing, is carried on in a considerably different manner from that of the common flint-glass ar-

ticles, as the object is to produce a large flat very thin plate of glass, which is afterwards cut by the glaziers' diamond into the requisite shape. The steps of the process could not be understood by mere description, but it may just be mentioned, that the workman first takes a very large mass of glass on the hollow iron rod, and by rolling it on an iron plate and swinging it backwards and forwards causes it to lengthen by its own weight into a cylinder, which is then made hollow by blowing with a force of breath which only those that are used to the business can command, and is brought out to the requisite thinness. The hollow cylinder is then opened by holding it to the fire, which by expanding the air confined within it (the hole of the iron rod being stopped) bursts it at the weakest part, and when still soft it is ripped up through its whole length by iron shears, opened out into a flat plate, and finished by annealing as usual.

Common green bottle glass is another kind, which indeed is by no means uniform in its composition, but is made almost entirely of sand, lime, and sometimes clay, and alkaline ashes of any kind according as cheapness or convenience direct, and more especially of kelp in this country, of barilla, varec and the other varieties of soda in France, and of wood-ashes in many parts of Germany and the like. To this too is sometimes added even the earth remaining from saline ashes, after the alkali and salts have been extracted by lixiviation, and in England flags from the iron furnaces. This refuse matter is still a flux of some power when in mixture with other earths, and it still retains a small quantity of salts which are not totally extracted. Bottle glass is a very hard well-vitrified glass, not very heavy relatively to its bulk and being fused at a very high heat, and from the impurity of the alkali and the abundance of earthy flux, containing but a small proportion of real saline matter, it resists the corrosive action of all liquids much better than flint-glass. Besides being used for wine bottles it is much employed for very large retorts, subliming vessels, and other processes of chemical manufacture, and here too is has the additional advantage of bearing as much as a pretty full red heat without melting or sinking down into a shapeless lump as the lead glasses would do. The following composition is given by Loysel as a good and cheap material for bottle glass, 100 parts common sand, 30 of varec (a kind of coarse kelp made on the western coasts of France,) 160 of the lixiviated earth of ashes, 30 of fresh wood-ashes or any other kind of ashes, 80 of brick-clay, and any quantity, generally about 100, of broken glass. This composition gives no glass-gall.

A good bottle glass, but nearly black and opake, has been made in France of another material which probably may be applied in many countries advantageously: it is the decomposed pulverulent basaltic earth found in the vallies of all basaltic countries. In France it abounds in the Vivarais, in Languedoc and Auvergne. The first glass of this kind appears to have been made in 1780, by a M. Ducros, at the suggestion of Chaptal, who simply melted some of this basalt without addition in a glass-pot, and formed of it two very light, black, or rather deep yellow, shining, perfect bottles. In subsequent trials by another artist a mixture of equal parts of basalt and sand was employed, as being preferable to the basalt alone, and for awhile there was a very considerable demand for bottles of this material, but the manufacture was abandoned owing to the want of uniformity in the ingredients, which made them often fail. The glass produced hereby was of a green olive.

It may not be uninteresting also to give the results of some experiments of M. Alliot on different mixtures of this basaltic earth. Seven crucibles filled with different mixtures were heated for eighteen hours in a common potter's furnace (a glass-house not being at command,) which however gives a less intense heat than the glass furnaces, and therefore if used in manufacture a greater effect might be allowed than was here noticed. The results were the following:

No. 1. contained the pure basaltic earth, and melted into a black, opake glass, moderately well melted.

No. 2. was a mixture of one-third basalt, one-third of ashes, and one-third of white quartz in powder. It was a milky, brilliant, coffee-coloured glass resembling fine porcelain.

No. 3. was a mixture, in equal parts, of basalt and common sand. It was moderately well melted, of a blackish-blue in mass, but in thin laminæ was of a yellow-green.

No. 4. was a mixture, in equal parts, of ashes and a volcanic granite. It melted well, gave a very fine dark yellow glass, of great lustre, and would have been very proper for bottles.

No. 5. contained one-nineteenth of ordinary soda, six-nineteenths of common sand, and twelve-nineteenths of ashes, and gave a yellow-black glass interspersed with opake blueish white veins.

No. 6. consisted of one-third basalt, one-third of refuse soda, and one-third of sand. It gave a fine transparent green-yellow glass, very well melted, of a fine polish, and which would have been excellent for bottles.

No. 7. was simply the sand of the river Orb in the neighbourhood, which appeared by inspection to contain a large proportion of basaltic earth. It melted well and gave a very good bottle glass.

The analysis of basalt shews that it is very well fitted both for fusion *per se*, and to act as a flux of considerable power, for (as mentioned under that article) it consists of about 45 per cent. of silex, 16 of alumine, from 16 to 20 of oxyd of iron, 9 of lime, and from 2.6 to 4. of pure soda, of which the three last are all very powerful fluxes. Many other minerals contain even more soda, such as the Klingstein, which contains about 8 per cent. of this alkali, but having much less lime and oxyd of iron it is much less fusible. The colour of all the glasses into which basalt enters largely as a constituent is generally of a deep olive green passing to deep yellow, and in mass almost yellow, nor is it probable that this colour could be materially corrected. The glass is well ascertained to be specifically lighter than common green bottle glass but at the same time tougher, so as to bear harder blows without breaking, two very important advantages, and the quantity of alkali contained and that required to bring the whole to a workable state is so small as probably to enable this glass to resist all corrosive liquors, at least as well as any other known kind of glass.

Plate glass is that most beautiful and perfect glass of which all the kinds of mirrors and looking-glasses are composed, and of which the larger articles are wrought, not by blowing as every other glass article is, but by casting the melted glass on a flat table.

The Venetians were long in the sole possession of the art of making mirror-glass, but by them it was only manufactured by blowing, nearly in the way described under crown or window glass, and much of the common mirror glass is still prepared in this way.

In 1665 under the ministry of the great Colbert a company for *blown-mirror glass* was first established near Cherbourg in Normandy, on the plan of the Venetian manufacture, but the beautiful art of casting glass was invented in France about 1688, by one Abraham Thevart, and a company was soon established for this branch of manufacture which was first carried on at Paris, and soon after removed to St. Gobin, where it still exists in full activity, and undiminished reputation.

The plate-glass cannot be made by blowing of the larger size than about fifty inches to be perfect, but by the ingenious substitution of casting it may be made so large and at the same time so perfect, that scarcely any other limits can be set to the possible size of these plates than the heavy expence of the manufacture, in all its parts. As large plates as nine feet long, and wide in proportion, have been manufactured.

As this art of casting glass requires more care in the choice of materials and nicety in the processes of manufacture than most other branches of glass-making, some more detailed account may be given of it as carried on in France, as far as it can be understood without reference to plates.

The materials of the finest plate glass are white sand, soda, and lime, to which are added manganese and zaffre, or any other oxyd of cobalt for particular colouring purposes, which will be presently described. The sand is of the finest and whitest kind, and is previously passed through a wire sieve of moderate closeness into water where it is well stirred about and washed till all dirt and impurity is got rid of. The sharpest grained sand is preferred, and indeed it is found that the grains of moderate size melt with the alkali sooner than either the very fine dust or the larger fragments, in the former case the sand clotting together without mixing freely with the alkali, and in the latter the grains taking a longer time to dissolve on account of their bulk. The alkali used here is always soda, and there seems good reason to prefer this to potash, as glasses made with soda are found to be softer and to flow thinner when hot, and yet to be equally durable when cold, and in casting a large plate, of which the perfection is to be without streak or bubble, it is obvious of how much importance it must be to have it flow extremely liquid from the pot. Besides, the neutral salts with the basis of soda which constitute the glass-gall in this instance, such as the muriat and sulphat of soda, appear to be dissipated more readily by the fire than the corresponding salts of potash. The soda used here is considerably pure, or such as is separated from the rough ashes of barilla, and other soda plants by lixiviation.

Lime is of considerable use here and adds much to the fusibility of the other materials, supplying in this respect the

use of litharge in the flint-glass. Too much lime however impairs the colour and solidity of the glass. About one fifteenth of the whole is as much lime as can be used with propriety, and some use as little as one twenty-fourth

The colouring or rather decolouring substances used are *azure*, or cobalt blue, and manganese. The latter is here in the state in which its effect is that of giving a slight red tinge, which mixes with the blue of the cobalt and the natural slight yellow of the other materials, and altogether are found, when properly proportioned, to neutralize each other so that scarcely any definable tint remains.

Besides these ingredients there is always a great quantity of fragments of glass arising from what is split in the casting and the ends cut off in shaping the plates, which are made friable by quenching in water when hot and used in this state along with the fresh materials.

With regard to the proportions of the ingredients very considerable latitude may be allowed. The quantity of soda is a good deal more than necessary merely to produce a good glass, as one of great fusibility is required. The following proportions are found to produce a very fine glass: 300 lbs. of sand; 200 lbs. of soda; 30 lbs. of lime; 32 ounces of manganese; 3 ounces of azure; and 300 lbs. of fragments of glass.

It does not appear whether or not any other fluxes are used, though there seems to be some secrecy observed in this respect at the manufactory of St. Gobin It is constantly asserted and with much probability, that borax is also used in small quantity. This is in itself highly probable, as the very thin watery fusion which this flux gives to vitrifying matters seems peculiarly wanted in glass intended to be cast, and probably this addition would enable the manufacturer to use potash with as much advantage as soda where it happened to be cheaper.

Of the above materials the sand, soda, lime and manganese are first mixed together with more care than for ordinary glass, and are fritted in small furnaces built for this express purpose, the heat being gradually raised to a full red-white, and kept at this point with frequent stirring till the materials undergo no further change, nor give any kind of vapour. The azure and the glass fragments being already perfectly vitrified are not added till just at the end of the process, which lasts about six hours.

The glass-house for this manufacture differs in several particulars from the common houses for blowing glass. The furnace at St. Gobin is about 18 feet long and 15 wide, made of good bricks. They are particularly distinguished from the common furnaces by containing two kinds of crucibles, the larger ones called *pots* are in the form of an inverted and truncated cone, and in these the glass is melted. The other set of crucibles are smaller ones called *cuvettes*, the capacity of which is not more than a sixth, or where very large plates are cast, a third, of the pots, and are kept in the furnace empty, but quite hot, till the glass is ready for casting, when they are filled out of the furnace on an iron cradle to the heated table or bed on which the glass is cast. Both the pots and the cuvettes are of the same material, of good refractory clay. Another essential part of this furnace is the flat table (of which there is one corresponding with each pot) on which the glass is cast. These tables are of smooth thick copper plate about ten feet by six, strongly supported by masonry; and contiguous to each table on the same level are flat ovens, heated from underneath, upon which the glass when cast and sufficiently cooled, may be slid without difficulty from off the copper table and there annealed. The tops of the flat ovens and the tables are on a level with the corresponding opening of the furnace whence the cuvettes are withdrawn. The fuel used is wood, and the kind which makes the largest and brightest flame, but without giving much resinous smoke is preferred. It requires about thirty-six hours of strong heat from the time of filling the pots till the glass is fit for casting.

The process of filling the pots and the appearances that take place in the melting materials, the rising of the glass-gall, refining, &c. need not be described, being the same as in other glass-making.

When the glass is thoroughly melted and fine, the proceedings are in a general way as follows: the cuvette (which has been previously emptied of all the loose glass and foulness which may have adhered to it and again made quite hot in its place in the furnace) is filled in the following way; the workman takes a copper ladle about ten inches in diameter and fixed to an iron handle seven feet long, plunges it into the glass pot (the contents of which have been previously scummed carefully) brings it up full of the melted glass, and empties it into the cuvette, the ladle being supported at the bottom by a strong iron rest, held by two other workmen, lest the red-hot copper should bend and give way with the weight of the glass within. The cuvette being filled by repeated lading is then suffered

to remain in the furnace for some hours, that the bubbles formed by this disturbance of the glass may have entirely disappeared, and the samples taken out from time to time become quite clear and limpid. The door of the furnace is now opened, the cuvette is slid out and pulled upon a low iron cradle and immediately drawn on to the side of the copper table, previously heated by hot ashes and wiped quite clean. The cuvette full of the melted glass is then carefully scummed by a broad *sabre*, or copper blade set in iron, which carries off with it every impurity at the surface. The reason of using copper for this as for the ladle and casting table is that it does not discolour the hot glass as iron does. The cuvette is then hoisted up by a tackle and iron chains, and overset upon the copper table, on which a thick flood of melted glass flows and spreads in every direction to an equal thickness. It is then made quite smooth and uniform at the surface, by passing over it while still quite hot a heavy hollow roller or cylinder of copper made true and smooth by turning after it is cast, and weighing about 500 lbs. At the same time the empty cuvette is returned by the iron cradle to its proper place within the furnace. The edges of the copper table overhang a reservoir of water into which the waste glass falls in drops, and is used for the next melting. The number of workmen required for the whole process of casting is at least twenty, each of which has his separate employment.

The plate being cast, the inspector examines whether there are any bubbles on any part of the surface, and if found, the plate is immediately cut up through them. The plate being now so far cool as to be stiffened is slid by an iron instrument from the casting table to the contiguous annealing oven, previously well heated, and is carefully taken up and ranged properly within it. Each oven will contain six entire plates, and when full, all the openings are stopped with clay and the plates allowed to remain there for a fortnight, to be thoroughly annealed.

When fit to be taken out of the annealing oven, they are sent away to receive all the subsequent operations of polishing, silvering, &c. but first their edges are cut smooth and squared. This is done by a rough diamond which is passed along the surface of the glass upon a square ruler in the manner of glaziers, and made to cut into the substance of the glass to a certain depth. The cut is then opened by gently knocking with a small hammer on the under side of the glass just beneath, and the piece comes off, and the roughnesses of the edges are removed by pincers. The plate is then finished as far as the glass-house business is concerned, and is carefully removed to the warehouse.

The subsequent operations of polishing and silvering, may here be added in a few words. The plate is first exactly squared by the diamond in the way mentioned above, and minutely examined as to any flaws or faults, which may be found. The next step is to grind off all the inequalities and roughnesses of surface previous to the polishing. This is done on both sides by sand and water. For this the plate is laid on a thin plate of free-stone, or on a long wooden frame, of about the same size with it, and cemented strongly thereto by Paris plaster. Another plate is also cemented in the same manner, and laid upon the lower plate, and wet sand is interspersed between the two. The plates are then made to rub against each other steadily and evenly, by a kind of hand mill, the wheel of which is worked by a man, or sometimes in large plates by two men, who can regulate the pressure of one on the other as it may be judged proper. In proportion as the surfaces of the plates wear down, the sand is used successively finer, being previously sifted and sorted for the purpose. In general,, the workmen avoid rubbing two absolutely rough surfaces on the other, for fear that the great jarring of the friction should produce shakes and flaws in the glass, but a half ground plate is rubbed on a fresh surface and so on successively.

When one side of the plate is done, the plaster which cemented it is picked off, the plate turned, and the opposite side ground in the same manner. Towards the end of the grinding, the pressure is encreased by loading the upper plates with flat stones of different thicknesses. This process lasts about three days, and great attention is paid to finish them with surfaces, perfectly flat and parallel, which is determined by the ruler and plumb-line. The ground surfaces are now uniformly worn by millions of scratches, and therefore nearly opake, unless held up to the light, but still very far from having the requisite fineness to receive the polish. This further grinding is done by emery of different degrees of fineness, the preparation and sorting of which is done in the following very simple manner. A large quantity of rough emery is put into a vessel with water, and strongly stirred about till the whole is mixed. But, as emery is absolutely insoluble in water, the whole will again be deposited in successive layers, the coarsest particles sinking first,

and the others afterwards in the inverse degree of their fineness. By standing about twenty minutes, and then pouring off the supernatant liquor, the latter holds suspended only the very finest particles which again separate by rest for a longer time. More water is then added to the vessel, the emery stirred again, and now allowed to remain at rest only for fifteen minutes, and the supernatant turbid liquor again poured off This furnishes, by rest, an emery of the second degree of fineness The same is repeated twice more at the different times of about five minutes and half a minute, by which two other sorts are obtained. The wet emery from all these liquors is separately heated over a stove, to evaporate the water, and when nearly dry is made up into balls, in which state it is distributed to the workmen.

The plates are then further ground on both sides, with two or three emerys, beginning with the coarsest, and are finished with great care. They are now perfectly even, with a deadening or opacity on their surface, but so fine, that no scratches can be perceived. In this state they are again examined, and if any material defects still remain below the ground surface, they are cut up with the diamond into smaller plates, with the greatest economy possible, the diamond now dividing them with much greater ease than before, both on account of the quantity of substance of glass removed, snd the uniformity of the surface.

The next process is that of polishing both surfaces to that perfect brightness which is seen in finished mirrors, so that the rays of light may pass through unimpaired to the silvering on the posterior surface, and be reflected again from thence, according to the laws of catoptrics. The substance used to give this last polish, is colcothar, imported from England, and called *rouge d'Angleterre* or *Potée*. It is the residue left in the retorts of the aqua-fortis makers, and when well washed and levigated, consists of little else than a red and perfect oxyd of iron.

The polishing instrument is a block of wood, covered with several folds of black cloth, with carded wool between each fold, so as to make a firm elastic cushion. This block has a handle for the workman to hold; for the whole of this part is done by hand, and not by machinery, as the latter would work too uniformly, and not allow of that variation of pressure, and those finishing touches, which are required to bring every part of the glass to exactly the same height of polish. But to encrease the pressure of the polisher without fatiguing the workman, the handle is lengthened by a wooden spring, bent to a bow, and three or four feet long, which at the other extremity, rests against a fixed point, in a beam placed above. The plate being fixed on the table by plaster, he then moistens the polisher with a wet brush, covers it with colcothar, and begins his operation by working it backwards and forwards, over the surface of the plate. Much practical skill and dexterity is required, to give an uniform and high degree of polish, over the surface of a large plate, as it must be done by separate portions, and the finishing touches given with great care. The glasses of moderate size, are compleated in four portions, from corner to corner, the centers of which intermingle so as to leave no part untouched, but the larger glasses require additional polishing in the center. When one side is completed and the reverse is about to be done, the polished side, now the undermost, is entirely covered with the red colcothar, to prevent the dazzle reflected from the white plaster, which would prevent the workman from judging so accurately of the state of the surfaces on which he is employed. When both sides of the glass are thus brought to the same perfection of polish, the operation is finished by inspecting the glass, first cleaning both surfaces, and laying it, each side alternately upwards, upon a dark blue or black cloth, admitting only a moderate light, and if any part appear less highly finished than the rest, it is retouched by a small hand-polisher, and colcothar, as before.

When a number of smaller pieces of glass, such as are used only for chamber or similar mirrors, are to be polished, they are laid together on the table, and several of them polished at a time. But, as these consist of pieces often of unequal thickness, though their surfaces have been rendered perfectly flat by the previous grinding, if they were simply placed side by side, and fixed on the table by plaster, as usual, the polisher would not work well over such a variety of heights, and would act chiefly on the edges of each piece of plate. Therefore, they are all first arranged on a large smooth plate, finished all but the polishing, and previously wetted, and plaster, is poured upon them, by which they are fixed together, and then when taken off, the surfaces which were in contact with the plate, are perfectly level with each other, and the polishing goes on with the same ease, as on an entire plate.

What is termed *silvering* of mirrors, is applying to the posterior surface a coat-

ing of quicksilver, which metal, when perfectly bright and brilliant, reflects the rays of light with great accuracy and beauty. But, as this fluid metal could not be alone applied without great inconvenience, it is first made to adhere by a partial amalgamation to the surface of a a sheet of tin-leaf, and then by the help of pressure, is applied closely to the glass in a very thin lamina. It is therefore, properly, a thin sheet of tin, fully impregnated with mercury, which is the reflecting surface.

The management of the silvering is extremely simple. A perfectly flat slab of smoothed free stone (or sometimes of thick wood) a little larger than the largest plate, is inclosed in a square wooden frame, or box, open at top, and with a ledge rising a few inches on three sides, and cut down even with the stone on the fourth. A small channel, or gutter, is cut at bottom of the wooden frame, serving to convey the waste mercury down into a vessel below, set to catch it. The slab is also fixed on a centre pivot, so that one end may be raised by wedges (and of course the other depressed) at pleasure, when working freely in the box.

The slab being first laid quite horizontal, and covered with grey paper stretched tight over it, a sheet of tin-foil, a little bigger than the plate to be silvered is spread over it, and every crease smoothed down carefully; a little mercury is then laid upon it, and spread over with a tight roll of cloth, immediately after which as much mercury is poured over it as will lie on the flat surface without spilling. That part of the slab which is opposite the cut-down side of the wooden frame, is then covered with parchment, and the glass plates lifted up with care and slid in (holding it quite horizontally) over the parchment, and lodged on the surface of the slab. The particular care required here is, that the under surface of the glass should from the first just dip into the surface of the mercury (skimming it off as it were) but without touching the tin leaf in its passage which it might tear. By this means no bubbles of air can get between the glass and the metal, and also any little dust or oxyd floating on the mercury is swept off before the plate without interfering. The plate being then let go sinks on the tin-foil, squeezing out the superfluous mercury, which passes into the channel of the wooden frame abovementioned. The plate is then covered with a thick flannel and is loaded over the whole surface with lead or iron weights, and at the same time is tilted up a little, by which still more of the mercury is squeezed out. It remains in this situation for a day, the slope of the stone slab being gradually increased to favour the dripping of the mercury. The plate is then very cautiously removed, touching it only by the edges and upper side, and the under side is found uniformly covered with a soft pasty amalgam consisting of the tin-leaf thoroughly soaked with the quicksilver, and about the thickness of parchment. It is then set up in a wooden frame, and allowed to remain there for several days, the slope of its position being gradually encreased, till the amalgam is sufficiently hardened to adhere so firmly as not to be removed by slight scratches, after which the plate is finished and fit for framing.

It is a considerable time before the amalgam has acquired its utmost degree of hardness, so that globules of mercury will often drip from new mirrors some time after they have been set up in rooms, and violent concussions of the air, such as from the firing of cannon, will often detach portions of the amalgam. These can never be perfectly replaced by any patching, as the lines of junction with the old amalgam will always be marked by white seams seen when looking into the glass. See Foliating of Glass.

Of working glass with the lamp and blow-pipe.—A great variety of small articles of glass for philosophical purposes, such as thermometers and barometers, and many ingenious toys, are made out of glass tubes by the blow-pipe, and some short account of the general method of proceeding may here be added.

The usual apparatus of the glass lamp-blowers is very simple. It consists of a solid table, at the bottom of which is fixed a double bellows with a foot-board, that the artist may work it with his foot and keep both his hands at liberty, whence proceeds a pipe which conducts the blast to the lamp, which is a large bundle of cotton thread lying in a tin vessel of a horse-shoe shape and fed with lumps of tallow heaped up beside it. These are from time to time drawn forwards into the flame, to keep up the combustion. A small chimney hangs a little way over the lamp to carry off the smoke. The blast-pipe comes up in front of the table where the artist sits, and drives the jet of flame in a contrary direction to his body, so that he is not in the least incommoded by it. All the rest of his apparatus consists of an assortment of glass tubes of different bores and thicknesses of glass (made at the glass-house, by pulling out rather suddenly a bottle of blown glass when

still quite soft) and two or three very simple iron tools, such as small forceps, files, &c. Any other method of working the blow-pipe may be adopted that will give a very large and powerful flame. The flame, when in full vigour, is a jet of fire about four inches long, not sharp-pointed, but like a blunt rounded spear-head, which near its extremity is of a clear light blue, and beyond, of a pale yellow. The blue part is the hottest. As general rules, for managing the working, the tubes should never have any moisture introduced into them, and should be well-dried on the outside before working. They are to be heated gradually (with more care in proportion to the thickness) first by being held in the flame of the lamp without blowing, and then at the edge of the outer yellow part of the jet of flame, and slowly brought to fusion. The flame is strong enough to bring to a very white-red heat, a solid mass of glass about as big as a child's playing marble, or even larger, which when blown out very thin, will make a bulb of the capacity of full three ounces, and this is nearly the extent of the power of the common lamp-blowing. But the bulbs for thermometers, or other philosophical purposes are much less. Two or three of the commonest operations may be described.

To seal a tube hermetically, if small, it is sufficient to hold it in the flame for a little time, slowly turning it round, when the end will melt, and falling in, will close the cavity with a neat button. This may be assisted by pushing the softened ends in towards the common centre with an iron needle. But if the tube be very large, this button would be too clumsy, and being thick would be in danger of breaking on cooling. It is therefore necessary to lessen the quantity of glass, which is done in the following way: soften the end of the tube in the flame, and apply to it a piece of another tube of nearly the same size (fragments of tubes being always abundant in this business) which will stick firmly to it. Then soften the tube to be sealed a little higher up than the point of juncture, and pull the two slowly in contrary directions till they separate. The tube will then draw out at the heated part into two short thin funnels, and a little turning and management of the flame will readily seal that which is wanted, leaving the joined ends and about half an inch of the lower part of the tube on the waste piece.

To bend a tube, if of a narrow bore and the glass is pretty thick, it is only necessary to hold it in the weaker part of the flame, and soften it for about an inch or two of its length, and bend it slowly into the required shape. In this way barometer tubes are bent. But if the tube be wide, and the glass thin, this way of bending entirely destroys the cylindrical form of the bore at the bent part, making a double flattening. To avoid this, first seal up one end of the tube, and then, whilst bending it at the required part, blow steadily and gently into the open end, and the pressure of the breath will counteract the falling in of the sides of the bending portion, and keep the bore cylindrical. The closed end is then cut off by the file, to do which make a deep scratch with one edge of a fine three-cornered file on the part intended to be cut, then break the tube with a smart pull in that direction in which the scratched part will be outermost, and it will separate in general with great accuracy at this point.

To join two tubes, heat them both in the flame, and apply them together when white hot, turning them round to finish the consolidation, or else to avoid the thick ring of glass which this produces, previously close one end of one tube, and when the two are fully joined blow into the open end of the other tube, and pull them out a little at the point of juncture, till an equal cylinder is formed.

To form a bulb (of a thermometer for example) choose a tube of a very equal bore, seal the end in the usual manner, and to collect a greater mass of glass at the end, press upwards on it while quite hot with any iron instrument so as to consolidate and shorten it a little; let it remain in the hottest part of the flame till the lump of glass is quite hot, then remove it, put your lips to the open end without loss of time, holding it with the hot part lowest, and blow moderately and steadily. The lump of hot glass will immediately open into a bulb, the size of which can be regulated at pleasure.

Glass may be spun out into threads of almost indefinite minuteness by means of the blow-pipe. When no thicker than fine hair, it is extremely flexible and elastic, and if still finer it may be wound almost like common thread without breaking. The way of doing it is very simple. A piece of glass tube is heated in the lamp, and the end drawn out into a thread by means of another piece of glass cemented to it. When a fine thread is once drawn, the end is carried round a reel or wheel two or three feet in diameter, and by turning the wheel and continuing to heat the tube, an endless thread is drawn out, winding round it as long as the ar-

tist pleases or the glass lasts. The quicker the wheel revolves, and the hotter the glass is kept, the firmer is the thread, which may thus be made as delicate as a single silk-worm's thread, with extreme flexibility. Different coloured threads are made in this way by using very deeply coloured glasses instead of common glass.

A singular change occurs in the texture of glass, more particularly of green bottle glass, made only of sand, lime, and saline ashes, when exposed for some time to a moderate red heat, or any higher temperature, but below its melting point. This is peculiarly observable when it has been in contact with sand, and hence it frequently takes place in green glass retorts long exposed to a high heat in sand-bath distillations. Neuman appears the first who noticed this change, which was afterwards examined more at large by Reaumur, and from the porcellaneous texture which the glass assumes when thus changed, it has been commonly called *Reaumur's porcelain.* This ingenious philosopher had the idea that much advantage might be made of this fact in rendering glass much tougher and less liable to crack from changes of heat and cold. No use however has been made of it in manufacture, but as a curious chemical or physical phenomenon it deserves further notice.

Dr. Lewis made the following very valuable experiments on this substance. A number of pieces of common quart bottles were put into crucibles, with white sand poured over them, and put into a proper furnace, where they were heated for many hours, and pieces withdrawn from time to time, to examine the progress of the change. The pieces that were taken out, after many hours heating, but *below redness*, did not appear to have suffered any change whatever. In a low red heat, the change went on, though very slowly; but, in a strong red heat, approaching to whiteness, just not sufficient to melt the glass, the change went on pretty fast, and in two hours the glass had assumed the appearance of porcelain, the change beginning at each surface, and spreading gradually to the middle.

The glass first became blueish on the surface, and, when held to the light, yellowish, and with a very sensible diminution of its transparency. After this, it gradually became white and opake, and the texture was no longer vitreous, but fibrous, and the fibres disposed nearly parallel to each other. By degrees, the glass became throughout opake and fibrous, and the colour of a dun white; the fibres were arranged regularly from the sides to the middle, where the fibres from the two sides meeting, formed a kind of partition, in which, occasionally, were pretty large cavities. A longer continuance of fire, induced a further change of texture, the fibres became divided or cut into grains at the outer ends, and gradually through their whole length, and the whole substance changed in texture, from fibrous to granular, like common porcelain. By a still further continuance of fire, the grains, at first fine and glossy, grew larger and duller, from being very compact, became porous, and at last, a friable substance like a slightly cohering mass of white sand, not easy to be distinguished from the sand in which it was imbedded.

Glass thus changed whilst it remains in the fibrous state, is considerably tougher and harder, so as to give abundant sparks with steel, which common green bottle glass will hardly do, to cut all common glass with ease, and scarcely to be scratched by the file. It will bear also to be plunged suddenly from freezing to boiling water, without cracking; and, at the same time, its texture is so dense, that no acrid liquors whatever, either corrode it, or transude through it. The circumstance which the most prevents its use in manufacture is, that though the inner texture is fine and white, the outer is coarse and dirty-looking. When the heat is so long continued that the texture changes from fibrous to granular, it again becomes soft, no longer gives fire with steel, and loses its cohesion.

Another important circumstance to be observed is, that when this fibrous porcellaneous glass is exposed to a very strong heat, it melts into a semi-transparent mass, drawing out in strings, which on breaking, are now no longer fibrous, but have *returned to the vitreous state*, and at the same time again becomes no harder than the glass from which it was originally made. However, it does not melt so easily as the glass itself; and the longer it is cemented, the more difficult of fusion it becomes, so that the granular porcelain requires a much higher heat for melting than the fibrous.

Dr. Lewis repeated the experiments, imbedding the glass in a variety of substances, instead of sand, such as bone-ash, charcoal, chalk, &c. but in all the change of texture was the same, the outer colour alone being affected. He then heated the glass by itself, being stuck up with a little luting in the middle of the crucible, and therefore touching nothing with the part above the luting. The same change

however, took place, though more slowly, and with some inconvenience from the falling in of some of the pieces when softened by the heat. The sand therefore, has little other effect than to support the glass during the process, and prevent it from losing its shape. Another important fact, to the explanation of the cause is, that the glass does not sensibly lose or gain weight in the whole conversion, from the vitreous to the fibrous state.

Mr. Gregory Watt, in his most valuable paper on Basalt, very happily brings this porcellaneous change of glass, as an illustration of his important position, namely, that bodies, whose fibres have a natural tendency to a crystalline arrangement, or a polarity, when vitrified by a sufficient heat, and cooled hastily in the vitreous state, are able subsequently to return to their natural crystalline arrangement of fibre, when exposed to a heat merely sufficient to soften the texture, though not enough for fusion. This, in the instance of basalt, he shews, by the singular crystallizations formed in the cells of fused basalt, long after it had lost the liquidity of fusion. The circumstance of no material change occurring in the weight of glass by this conversion into the fibrous state, shews incontestibly, that it cannot be owing either to any thing gained during the process, nor to any material loss of the alkali, and this is also rendered manifest by its return to the vitreous state, and vitreous qualities, when again melted. This too, may again be porcellanized in the same way, and again be melted into glass, and so on alternately.

Glass has been often found crystallized quite at the bottom of the pots, and in places where it has cooled, undisturbed, for a length of time. This is particularly the case in that mass of refuse and spilled glass, with ashes, melted drops from the clay of the furnaces and pots, &c. which falls down behind the pots in the furnace. This is generally raked out, but part of it remains; and, when the fire is let to go out, and the furnace is become useless, these crystallizations are usually found here. They are found in all kinds of glass, but less often in the fine flint and the very saline glasses, than in the coarser green and crown glasses.

The following interesting observations of Mr. Nicholson, concerning the principal defects observable in works made of glass, may be interesting to a portion of our readers:

The most considerable defects, as enumerated by Mr. Loysel, are striæ or veins, threads, tears, cords, bubbles, and knots.

The striæ or veins, arise from the heterogeneous composition of the glass. It seldom happens, that glasses of any considerable magnitude, are exempt from them, and the reason is not difficult to explain.

Glass produced by the solution of siliceous earth by fixed alkali, at the ordinary heat of the glass-house, possesses a specific gravity of 2·8 or 2·4, water being assumed as usual at one. Glass made with alkali, and the clay commonly used, weighs about 2·5. That of alkali and chalk, 2·7 or 2·8. The oxid of manganese vitrified alone, weighs 3.2 or 3·3. Glasses produced by other metallic oxides, are still more ponderous: that of lead, for example, weighs about 7·2 or 7·3. When the partial combinations of the ingredients of the glass are not well mixed together, but form strata of different density in the pots, they produce undulated veins in the work, similar to those observed when two liquids of very different densities are first mixed, such as water and alcohol.

As the glass in the operations of blowing is taken up nearly from the same part of the pot, and, as in the casting of glass, the pot is suddenly reversed, and its whole contents mixed together, it is found, that blown glass is much more uniform than that which has been cast.

The name of threads is particularly given to those veins which are produced by the vitrification of clay. They are greater than those produced by calcareous earth. These threads render the glass very brittle, when they are abundant, or when any of them are of considerable size, because the contraction and dilatation of this kind of glass, from change of temperature, are very different from those of the glass of sand and flint.

Tears are the greatest defect which can be found in glass. They are the drops of glass afforded by the vitrification of the furnace of fusion. Articles in which these are found are brittle. Most of them break by the alternations of temperature, and that the more surely, the nearer the tear is to the surface. Such articles are generally thrown aside in the glass-house.

Cords are asperities on the surface of certain articles of blown glass. They are produced whenever the heat of the furnace becomes so low, that the threads of glass which fall from the pipe into the crucible, cannot resume the proper degree of fluidity. When this appearance presents itself, the work is given up, till the heat of the furnace is again brought to the requisite degree.

The small bubbles abundantly diffused

through certain glasses, shew, that the refining is imperfect. They arise from the disengagement of elastic fluid during the vitrification. This imperfection shows, either that the quantity of flux has been too small, or the fire too weak, In the first case, the glass may be used to hold liquids without fear of being attacked; in the second, the glass is tender and easily acted on by acids, if the flux were of an alkaline nature, because its proportion is too great.

Bubbles may also be produced in glass, during the working, by certain foreign matters, which are fixed, and emit aerial fluids by the heat.

Knots are of three kinds. They are either formed by grains of sand enveloped in the glass, or by the salt of glass which is found in pieces, or white flocks; or lastly, by pieces detached from the crucible, or the sides of the furnace.

The fused glass has the property of sticking to an iron rod or tube, by which means it is taken out, either to ascertain its state of perfection, or to blow it into such utensils as may be wanted.

The quantity to be used at once, is regulated by a process somewhat resembling that of the tallow-chandlers; that is to say, the part first dipped out is suffered to cool a litttle, and serves as a receptacle for more glass to be taken up at a second dip, and so forth, until the quantity is sufficient. The lump of glass may be softened at pleasure, by holding it before the mouth of the furnace. The workman renders it hollow, and of a spherical form, by blowing through the tube. This sphere may be converted into a cone, a cylinder, or any other solid, the transverse section of which is a circle, by rolling it on a flat plate of iron. It may be stretched in length by swinging the tube in the air, or giving it a vibratory motion like that of a pendulum. The workmen shew great dexterity in heating the glass in the various stages of the manipulation. They do this in such parts as they are desirous of extending; and on other occasions they cool certain parts of their work, by fanning the air against it. The glass, in the ignited state it possesses, after it comes out of the pots, is very rough and flexible, may be cut with shears, bended with pincers, pressed into moulds, and wrought in a variety of methods dependent on these properties, of which the artists very dexterously avail themselves.

As far as observation has hitherto directed us, it appears to be a general rule, that the hardness, brittleness, elasticity, and other mechanical properties of congealed bodies, are greatly affected by the degree of rapidity with which they assume the solid state. This, which no doubt is referable to the property of crystallization, and its various modes, is remarkably seen in steel and other metals, and seems to obtain in glass. When a drop of glass is suffered to fall into water, it is found to possess the remarkable property of flying into minute pieces, the instant a small part of the tail is broken off. This, which is commonly distinguished by the name of Prince Rupert's drop, is similar to the philosophical phial, which is a small vessel of thick glass, suddenly cooled by exposure to the air. Such a vessel possesses the property of flying in pieces, when the smallest piece of flint or angular pebble is let fall into it, though a leaden bullet may be dropped into it from some height without injury. Many explanations have been offered, to account for these and other similar appearances, by referring to a supposed mechanism or arrangement of the particles, or sudden confinement of the matter of heat. The immediate cause, however, appears to be derived from the fact, that the dimensions of bodies suddenly cooled remain larger, than if the refrigeration had been more gradual. Thus the specific gravity of steel hardened by sudden cooling in water is less, and its dimensions consequently greater than that of the same steel gradually cooled. It is more than probable, that an effect of the same nature obtains in glass; so that the dimensions of the external and suddenly cooled surface remain larger than are suited to the accurate envelopement of the interior part, which is less slowly cooled. In most of the metals, the degree of flexibility they possess, must be sufficient to remedy this inaccuracy as it takes place; but in glass, which, though very elastic and flexible, is likewise excessively brittle, the adaptation of the parts, urged different ways by their disposition to retain their respective dimensions, and likewise to remain in contact by virtue of the cohesive attraction, can be maintained only by an elastic yielding of the whole, as far as may be, which will therefore remain in a state of tension. It is not therefore to be wondered at, that a solution of continuity of any part of the surface should destroy this equilibrium of elasticity; and that the sudden action of all the parts at once, of so brittle a material, should destroy the continuity of the whole, instead of producing an equilibrium of any other kind.

Though the facts relating to this disposition of glass too suddenly cooled, are numerous and interesting to the philosopher, yet they constitute a serious evil with re-

spect to the uses of this excellent material. The remedy of the glass-maker consists in annealing the several articles, which is done by placing them in a furnace above the furnace of fusion. The glasses are first put into the hottest part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this means the glass cools very slowly throughout, and is in a great measure, free from the defects of glass, which has been too hastily cooled.

It is difficult to speak with any precision concerning the materials, proportion, and management necessary to make the different kinds of glass, such as the green glass for bottles, the greenish or bluish glass for windows, the white glass for mirrors, the white flint glass for bottles, and the crystal glass used for the finer wares, called cut glass, not to mention the dense white glass made expressly for optical uses. All these are made of better quality at some manufactories than at others; and it is probable, that this superiority of produce is thus confined by the natural disposition for secrecy, which prevails among men, whose pecuniary success in a great measure depends on their monopolizing the effects of their own skill. Far be it from us to pretend to consider this proceeding as immoral. On the contrary, we very much doubt, whether any species of property can be defended under a title in any respect so strong as that which a man must hold in his own superiority of intellect and exertion. We mean simply to observe in this place, that, from the causes here mentioned, it is impossible to give a minute account of the art. The green glass is made from impure materials; the basis consisting of a ferruginous stone or sand, and the alkali being such as can be the most cheaply purchased. The colour chiefly depends on the iron; and the glass is harder, more durable, and less destructible by acids remaining in it for a long time, the less the quantity of alkali, and consequently the greater the heat. Pit coal is used as fuel in the English glass-houses It produces a more intense heat than wood. Chaptal, in his Elements of Chemistry, mentions the successful establishment of a manufactory of opake bottles of excessive strength and lightness, composed chiefly of basaltes; but he relates that the establishment failed, chiefly on account of the quality of the basaltes, which did not constantly prove the same, but, becoming in the latter stages of the undertaking more calcareous, produced an article of a perishable nature.

All the white glasses owe their clearness to the purity of the materials. The finest siliceous sand is fused with purified alkali. The oxides of lead act as a powerful flux, and are much used in compositions of this nature. They give density, softness, and a disposition to take a brilliant polish.

Optical writers teach us, that the refracting telescope consists of a convex lens, called the object lens, in the focus of which the image of a remote object is formed; and that this image is seen magnified and distinct by a microscope applied to it, which forms the apparatus at the other end of the telescope. It may easily be imagined, that, if the focal image be indistinct, or if there be a number of focal images occupying different parts of the field of view of the telescope, the effect will be less perfect, and the magnifying power must be less, in order that the confusion may be at all tolerable. Whenever a ray of white or compounded light is refracted out of its course, by passing into another simple medium of different density from that through which it originally passed, it is found to be separated into its component parts, which produce the sensations of various colours. This separation is made by virtue of the different properties possessed by the several rays of light, by which some are more refracted in like circumstances than others. Thus the blue is more refracted than the green and yellow, and these are more refracted than the red rays. Whence it follows, that a pencil of white light, which passed in parallel rays to a wedge or prism of glass, will come out of the prism on the other side, not only refracted in the whole, but differently refracted as to its parts; the red being less turned out of its course than any of the other rays, and the violet being the most deflected of any. And this difference of direction will be greater, the greater the mean refraction. The edges of a convex lens may be considered as wedges of the same nature, with regard to the light, as the prism here mentioned. Such a lens, refracting the red rays less than any other, will form a red image at a certain focal distance. The yellow rays, being somewhat more refracted, will afford a yellow image, at a distance less remote from the lens: and for similar reasons, there will be formed, at still nearer distances, images of green, blue, and violet, with all the intermediate shades of colour. The entire focal image will consist of all these images irregularly combined. It has been discovered, that the quantity of dispersion is greater in some kinds of glass than in others, while the

mean refraction or focal length remains the same. Two prisms of such different kinds of glass, producing the same mean refraction toward contrary parts on a ray of light, would not therefore correct the colorific dispersion, though the ray would proceed onward nearly in its original direction. It would be necessary, in order that this dispersion produced by the one glass should be accurately corrected by the other, that the mean refraction should be greatest in that which possessed the least power in dispersing the rays of light; and, in this case, the colourless emergent ray would not proceed in its first direction. To apply this doctrine to telescopes—suppose a convex lens formed of such glass as afforded very little colorific dispersion of the rays, and a concave lens of such glass as afforded much of this effect: it will follow, that, when these two lenses possess such a figure, as that the concave shall destroy the prismatic colours produced by the convex, the excess of mean refraction must be in the latter; and consequently, that the compound glass will act like a convex lens, and produce a real colourless focal image.

The problem of constructing telescopes which shall be truly achromatic, depends, as we have before observed, chiefly on the perfection to which the glasses can be brought. The general facts respecting glasses for this use are, that lead, and probably other metallic oxides, increase the dispersive power more than alkalis, and these last more than earthy fluxes; and that an addition of alkali to glasses containing lead serves greatly to diminish the mean refraction, without much affecting the dispersive power ocasioned by the metal. Hence it might seem easy to compose such glass as the theorems of the optician demand; but the practice is by no means so ready. Regular refraction demands, that the medium should possess a uniform density throughout, or, in other words, that the parts of the glass should be well combined together. This however is seldom the case, especially in the dense metallic glass. It is found, that the great fusibility of the glass of lead causes it to flow, and occupy the interstices between the particles of the sand before these are melted. So that some very bright and apparently homogeneous glasses exhibit an infinity of small focal images of a candle, when examined by a magnifier, which are produced by rounded particles of sand remaining in every part of the substance. Another fault, still more common, consists in veins of a different density from the rest, partly arising from imperfect fusion, and partly from the density of the glass in the pots being greater, the lower its position.

Various have been the attempts to remedy these defects, more especially since the Board of Longitude has offered a considerable premium for this object. We do not, however possess any ample detail of these unsuccessful experiments. It is generally understood, that it is vain to endeavour to make this glass in small furnaces, because the heat in these is continually varying, and is either too low for the requisite fluidity, or so high as to extricate bubbles of elastic matter; whereas a steady heat is required for the purpose. Macquer and others have attempted to correct the evil by repeated fusions and pulverization of the glass, and by exposing it to long continued fires, but without success. It is said, that one of the practices in the English glass-houses consists in lading the melted matter from one pot to another in the furnace. But this, on account of the heavy duty of excise, and the impolitic manner in which it is levied, cannot be done to any great extent in that country. If the glass be suffered to cool in the pots after a good fusion, its parts take a symmetrical arrangement, of the nature of crystallization, by which the light is acted upon in a manner independent of its figure, which is thought to be a great impediment to its optical use. Mr. Kier who has had much experience in this branch of chemistry, is disposed to recommend the trial of component parts different from any which have yet been admitted into the common glasses.

Without presuming to speculate in a department of science, wherein our experience is much confined, we shall point out a few facts, which may be of use to the philosophical operator, and leave the manufacturer to his own trials. It is generally affirmed, that Mr. Dollond made his original experiments, and constructed those excellent three-foot glasses (which at present bear so high a price, and are not to be made) with one single pot of glass made at the glass-house near Wellclose Square, and that none of the same quality has since been made. But the proprietor of that glass-house has assured us, that the original receipts and practice are still followed in the making of optical glass: that the principal opticians always complain of the bad quality of the glass, but never fail to take the whole quantity he makes at their request; and that when they renew their orders, they always desire it may be ex-

actly the same as the last. From these circumstances I think it probable, 1. That, though one pot of glass may differ from another, yet there may be as good glass obtained for optical uses now as formerly, if an optician skilled in the theory and practice, like the late Mr. Dollond, were to undertake the task of adapting the curvatures, and selecting the best lenses. 2. That Mr. Dollond's purpose as a tradesman being now answered, by the establishment of an extensive business, he has not the same motives for exertion upon powerful telescopes as actuated his father 3. That the profits of this trade are greater, and more certain, when many hundreds of cheap perspectives are made by common workmen, than when a few extraordinary telescopes are made by the most excellent artists, superintended by the master himself; and, consequently, it is not the interest of an established house to extend the latter branch. 4. That it is not the interest of a glass manufacturer, who can gain a large and regular income by making common utensils, to employ his time in costly experiments upon optical glass, which, if brought to perfection, would afford but a moderate demand, probably no greater than he now experiences: and, therefore, that the improvement of achromatic telescopes is rather to be expected from a man of science, who may be a practical chemist, than from a mere tradesman.

I suspect the opinion to be ill-founded, that those kinds of glass are unfit for optical uses, which are veiny or clouded, or otherwise unpromising. On the contrary, there are reasons to think, that the defects of glass arise from irregularities too minute and numerous to be discerned or discovered in any way, but by the actual proof of constructing a telescope. There are good glasses, which abound with the larger veins; and we possess two achromatic lenses, each of thirty inches focus, the obvious qualities of which, and excellence as object glasses, differ very much, and in opposite respects. They are each composed of a convex of crown glass, applied to a concave of flint. The one was constructed for the tube of an astronomical quadrant. It produces no colour, has no aberration from figure, and, when the eye is placed in its focus so as to receive the pencil of light from a fixed star, the whole aperture is uniformly covered with light. The other glass, though perfectly similar, was made for a pocket perspective. It produces scarcely any colour, has considerable aberration from figure, and when the eye placed in its focus receives the light of a fixed star, the whole aperture is covered with a light of an irregular, curdled, or cloudy appearance. I have no doubt but the former glass was applied to the superior, and the latter to the inferior use, from their obvious qualities: but when they are examined by the true test of optical excellence, the application of a large magnifying power, the former proves dark and indistinct, while the latter exhibits the object bright and well defined, and is on the whole an excellent lens.

Of Coloured Glasses.—The metallic oxyds when mixed with any of the glasses, dissolve in them with ease at a melting heat, and always change the colour more or less, sometimes producing very beautiful compounds, which when well prepared, have a lustre and richness of colour strongly resembling that of the natural gems, though in an inferior degree. The business of making these coloured glasses or artificial gems, is carried on to a very great extent in the manufacture of a variety of ornaments, and though much of the management remains a secret in the hands of the artists, a good deal of valuable matter has been made public by the labours of Neri, Kunckel, Margraaf, Fontanieu, and many other practical chemists.

It is very easy for any person at all used to chemical experiments to repeat most of these in the small way, with sufficient success to satisfy himself of the leading facts, though for the purpose of manufacture more care in the choice and preparation of the materials, and a greater length of time in the melting part is required than most experimenters choose to bestow.

It may be premised too, that the art of making coloured *enamels* is essentially the same as that of coloured glasses, the chief difference being that in the former case the *ground* or vitreous substance that receives the colour is an opaque enamel glass, and in the latter a clear transparent glass. The way of preparing the enamel ground is described under that article. The colouring power of the metallic oxyds is also in many instances much affected by the degree of heat to which they are exposed, and to the other ingredients with which they are mixed, and hence arise a good many precautions and niceties of management, many of which are only known to the practical artist. There seems good reason to suppose that much of this difference depends on the degree of oxygenation in which the colouring oxyd is left after the action of

fire, or of the other ingredients. The phenomena that occur in the use of manganese have already been described, and something similar happens in using the oxyds of iron and silver. Sometimes a metallic oxyd may be so nearly reduced to the reguline state, as not to be perfectly soluble in the glass, but only suspended in it. This happens occasionally with the oxyd of copper, which, when perfectly oxydated, gives a fine blueish-green, but when nearly in the metallic state produces a brown-red and not perfectly transparent glass. There is also a mutual action of the oxyds upon each other, so that the glasses in which oxyd of lead enters, will not receive a red colour by iron, an effect which is not produced with the merely alkaline glasses. Much remains to be done on this very curious and entertaining subject of the colouring power of metallic oxyds, and it is only by a well-conducted scientific series of experiments that the perplexing intricacy of many of the receipts of the articles on this subject can be reduced to certain rules.

In making coloured glasses to resemble artificial gems, the glass which is to receive the colour (which is often called *crystal*) ought to unite the qualities of great purity, lustre, and hardness, together with a sufficient fusibility to melt at a moderate heat those oxyds that are in danger of being decomposed by a high temperature. A vast variety of receipts have been given for such a glass, and it appears that several sorts are actually in use according to the price and object of the manufactured article. The glasses that possess the greatest lustre and are at the same time easily fusible, are unquestionably those in which the oxyd of lead enters very largely, and it appears that many of them are little else than oxyd of lead vitrified with a much smaller proportion of silex than is used even in flint-glass, or any other species. To these borax is an important addition, and often arsenic and other fluxes are added. But it unfortunately happens, that the lead-glasses are at the same time the softest, and scratch with the greatest ease. Hence it is the perfection of this art to find a compound, or manage any of the known compounds, in such a manner as to unite both lustre and hardness; in the former, the natural gems (the diamond excepted) may be very nearly equalled, but not in the latter.

Many of the older artists have had the idea that a harder glass would be obtained by making rock crystal the siliceous basis than sand, flint, or any other stone of this genus. But this seems totally unfounded; for when dissolved in a flux of any kind, the hardness of rock-crystal is irrecoverably lost, as it is not an inherent property of this particular species any otherwise than as depending upon its natural aggregation, which of course is destroyed. Perhaps it may be somewhat purer than the finest sand, or than powdered gun-flints, since these (the latter at least certainly) contain a very minute portion of iron, which possibly, though not very probably, may a little affect the very finest colours. It is rendered friable by being heated red-hot and quenched in water in the same way that gun-flints are. It should then be ground in a hard stone mortar, or in a mill, and not in any metallic mortar.

A few of these glasses may be here given from the directions of M. Fontanieu.

No. 1. Mix 20 parts of litharge, 12 of silex, 4 of nitre, 4 of borax, and 2 of white arsenic, frit them in a crucible and afterwards melt, then pour the whole into water, separate any revived lead that may be found, and melt again.

No. 2. Mix 20 parts of cerusse, 8 of silex (powdered gun-flints) 4 of carbonat of potash, and 2 of borax. When melted, pour into water, and re-melt in a clean crucible.

No. 3. Mix 16 parts of minium, 8 of rock-crystal in powder, 4 of nitre, and 4 of carbonat of potash; melt and re-melt as before.

No. 4. Treat as above 24 parts of borax, 8 parts of rock-crystal, and 8 of carbonat of potash.

No. 5. Make a quantity of liquor of flints by fritting together 3 parts of alkali with 1 of rock-crystal, which dissolve in water, and saturate with dilute nitric acid. Edulcorate and dry the silex which precipitates, and which is then in a very fine impalpable powder. Then melt it in a crucible with $1\frac{1}{2}$ its weight of very fine cerusse, and pour the glass into water. Then break it down and melt it with one-twelfth its weight of borax, and pour into water as before. Lastly melt this latter product with one-twelfth of nitre, and the result will be a very fine hard glass of extreme lustre.

Of the above glasses, No. 1 will be extremely soft and fusible, on account of the large proportion of flux, and it requires a very good crucible to withstand the corroding effect for a number of hours. The crucibles are found to stand better if they are first lined with any common glass without lead, for which purpose a little of the glass, No. 4, may be moistened with water, rubbed over the inside of the cru-

cible, slowly and thoroughly dried and heated red-hot before the mixture is added, which will give it an uniform glazing. Silex requires, to make a perfect and sufficiently workable glass, from 1½ to twice its weight of oxyd of lead; and a glass of this kind with a smaller quantity of oxyd of lead and a little other flux, will be very hard and brilliant, and will imitate the diamond when properly set, more than most other compositions.

The length of time required for fusion of the coloured glasses, appears to be, for the hard glasses or *pastes*, at least twenty-four hours, but the softer mixtures are thoroughly complete in a few hours. In the glass, No. 4, the silex is first directed to be reduced to the state of the greatest purity, and the most impalpable powder, by previous fusion with an excess of alkali, and precipitation by an excess of acid. It is seldom however that such extreme nicety of preparation can be required, and probably finely powdered flints would answer as well, or even fine sand. The process of pouring the melted glass into water, and re-melting, is used to mix the ingredients thoroughly, and is found by experience to have its use.

We shall now proceed to the colouring matters which (one excepted) are all metallic oxyds. We shall first mention the effect of the several metals individually, and then the method of producing the particular colours.

Of Gold.—This metal in the state of great division, and oxydated, has long been celebrated for giving to glass a most exquisite purplish-red resembling the ruby, and nearly equalling it in beauty. It is both the most expensive and the most splendid of all the artificial gems or coloured glasses, but the management seems to be extremely difficult to ensure the completest and most uniform success, principally, as may be supposed, from the great tendency of gold to assume the reguline state by mere heat, by any carbonaceous vapour, or by hydrogen. The most celebrated and the commonest preparation of gold for giving a purple to glass and porcelain, is the *purple precipitate of Cassius*, or gold precipitated from its nitro-muriatic solution, by, and together with, the oxyd of tin. The usual way of making it is, to dilute very largely a solution of gold in aqua-regia (formed by about 3 parts nitric and 1 muriatic acid) and add to it drop by drop a very dilute nitro-muriat of tin, well saturated with this metal. The liquors immediately become of a purplish red colour (like port wine and water) and by standing, a precipitate of this colour with some varieties of shade, slowly subsides. A similar precipitate also takes place with the nitro-muriat of gold and the pale muriat of tin, and also with great certainty by immersing a stick of tin in the dilute solution of gold. Though the change of colour always takes place when the nitro-muriat of tin is used, the precipitate sometimes fails to separate without any apparent reason. This substance is a most intimate mixture of the oxyds of tin and of gold, but the precise state of oxygenation of the tin is not well known, nor its exact use. It is certainly not essential to give the purple-red tinge to glass, since many other preparations of gold will produce it, in which not an atom of tin enters. Possibly the tin enables the gold to bear a longer continuance of heat, and a higher temperature, without reduction.

The precipitate formed by *metallic tin* and the solution of gold, may be supposed to be at a lower state of oxygenation than where the nitro-muriat of tin is employed, and probably it is always useful to add a little nitre to the powder before mixing to prevent the partial reduction of the gold by the heat. Neither copper nor silver, in small quantities, appear to injure the colouring power of gold.

Another preparation of this metal used in glass and porcelain colours, is the *fulminating gold*, prepared by precipitating this metal from its nitro-muriatic solution by ammonia. This preparation is known to explode most violently when raised to somewhat less than a tin melting heat, or even by moderate friction, but if kept for some time at a much lower temperature, being previously mixed with a fixed alkali, it loses its fulminating property, and may be safely used. A more manageable preparation of gold is the precipitate from the nitro-muriat of gold, by carbonat of potash, which is a brown-red or yellowish powder, and is not fulminating, provided the solution of gold be made with the muriatic acid, and not muriat of ammonia, for it is the presence of ammonia that is essential to the fulminating property. For the fine porcelain carmines, this carbonated oxyd of gold, as well as the decomposed fulminating gold, is mixed with luna cornea, and then with the proper quantity of saline flux, in which nitre and borax usually enter. The colouring power of these simple oxyds of gold, is nearly twelve times as strong as that of the purple precipitate, another proof that the tin does not of itself add to the body of colour. An ingenious way of producing a most intimate admixture of the oxyd of gold with silex, is to add the nitro-muriatic solution of the metal to the li-

quor silicum, or silicited alkali, and, if necessary, to add a further quantity of any acid to saturate the alkali. The silex is then precipitated in very intimate combination with the gold, and when washed and dried, is fit to be used as a colour, when mixed with nitre and borax or any other flux.

Whenever the purple precipitate by tin is used, it appears to be the practice to add about one-sixth of its weight of the perfect white oxyd of antimony by nitre, or else of the glass of antimony. This naturally gives a yellow; and it seems by experience to be a very important ingredient in the composition of the fine ruby glass. The particular rules for managing the fire in making this nice and difficult preparation, are known only to practical artists, but it can hardly be doubted that the peculiar risk is of giving too much heat, and thereby of destroying the colour altogether. All kind of smoke and other vapours should also be avoided. The finest ruby glass is said to come out of the crucible, when complete, quite colourless, but to assume its peculiar exquisite tint as it cools.

Of Silver.—All the oxyds of silver give naturally a yellow to vitrescent mixtures, which appears to be very pure and beautiful, but is not often used in the coloured glasses on account of the ease with which it is destroyed by too much heat. It seems to be chiefly used in the tender porcelain and enamel colours, where the eye of the artist can always be upon his work, and the heat is lower and much more manageable. In the latter case the oxyd of silver is generally mixed with a small quantity of alumine. The phosphat of silver formed by adding the nitrat of silver to the phosphat of soda, is also employed.

Of Iron.—The shades of colour produced by the oxyds of iron are very numerous. In the general account of glass-making it was observed, that a very small portion of iron, fully vitrified with a large body of glass, gave different shades of green and yellow, and to this the colour of common green bottle glass seems to be owing. A larger dose of iron gives a yellow after thorough vitrification, and a still larger gives a brownish black, which seems to be only a yellow very much concentrated, since this latter colour is again produced by diluting the brownish-black with a greater quantity of uncoloured glass. The oxyds of iron also produce a red upon enamel and porcelain, but as it appears, this is only owing to imperfect vitrification, that is to say, it is only red as long as it is merely *suspended* in the glass flux in a state of extreme division, for when by raising the heat a complete fusion of the oxyd is produced, the colour turns to yellow. This change is ingeniously prevented by combining the oxyd previously with alumine, by mixing the sulphat of iron and alum together in solution, and precipitating both together by carbonat of potash, as mentioned under the article ENAMEL.

A great many preparations of iron for these purposes have been given, particularly the *saffron of mars*, the *ethiops*, and the red oxyd precipitated from any of the solutions, all of which will be mentioned under the article IRON. It does not appear, however, that there is any certain foundation for preferring one to the other, for even the perfect oxyd by nitric acid, and which is itself of a dark red-brown, when fully vitrified produces a yellow or brown according to the dose, as well as any of the sub-oxyds. Brogniart asserts that the presence of the oxyd of lead singularly disposes the perfect oxyd of iron to lose its red or rose colour, for which it is used in enamelling, when urged by strong fire, but when no lead is present the colour is fixed.

Of copper. All the oxyds and carbonated oxyds of copper produce a fine green when thoroughly vitrified with any kind of glass or flux, and this colour is one of the easiest to produce in experiments in the small way. There does not seem to be much reason for preference of one preparation over the other. Those the most frequently employed are the carbonated oxyd produced by adding a carbonated alkali to the sulphat of copper, and also the æs ustum or copper oxydated and calcined simply by heat and access of air. This metal, however, may be made to give a carmine red (or mixed with iron a full deep red) by adding to glass containing it a quantity of tartar when in complete fusion and working off almost immediately. The oxyd of copper must in this case be reduced nearly to the reguline state. A greater continuance of the heat restores the green colour. The oxyd of copper is also often mixed with manganese and iron in the composition of the full-bodied black glass. This oxyd when combined with thrice its weight of alumine runs in a strong heat into an opake red enamel.

Of Lead. The oxyds of lead naturally give a yellow tinge to glass, but only considerably so when in very large quantity. Their use as a flux has been repeatedly mentioned, and they will readily vitrify most completely in a moderate heat without addition, or will unite with any other

vitrifiable matters and most powerfully assist their vitrification. This oxyd is seldom used directly as a colour, on account of the enormous proportion required, which should be at least three-fourths of the glass to give a yellow of an intensity, and this would give a compound extremely soft and one that would powerfully corrode the crucibles.

Of Antimony. The perfect oxyd of this metal gives a full yellow to glass which is much used, both alone and in compound colours in which yellow is a necessary ingredient.

Of Manganese. The peculiar circumstances attending the use of this metallic oxyd in glass-making have already been mentioned. When not in contact with carbonaceous matter the proper colour given by this oxyd to glass is a purplish-red, rather muddy when in full body, but still very beautiful. It is almost always combined with nitre when thus employed. The colour is totally destroyed by all the arsenical salts as before-mentioned, and therefore arsenic in any form should be avoided when manganese is used as a colouring matter. It also is the principal ingredient in most of the black glasses.

Of Cobalt. The colour given by the oxyd of this metal is a fine deep blue, which is unalterable in any fire, and succeeds with any flux. The colouring power is also very intense. Zaffre is usually employed for this purpose. Cobalt is also used for some of the finer blacks mixed with manganese and iron, and with the yellow of antimony and lead it composes a green.

Of Nickel. Though this oxyd is not actually used, it may here be mentioned, that the oxyd gives a violet-blue glass with fluxes of potash and to those glasses in which it largely enters, but not with soda or borax. Klaproth has fully ascertained this in his analysis of the Chrysoprase, which, from its giving a blue to potash glass, was thought to contain cobalt, but this is not the case, the colouring matter being nickel. Thus one part of the rough chrysoprase, and two parts of carbonat of potash fused into a violet-blue glass; and 80 parts of silex, 60 of carbonat of potash, and three of oxyd of nickel from the chrysoprase, also gave a violet-blue glass. The same result was given by using an oxyd of nickel from a known ore of that metal. Equal parts of the chrysoprase and of carbonat of soda gave a tourmaline-brown glass nearly opake. Equal parts of chrysoprase and calcined borax gave a brown transparent glass: and 60 parts of silex, as much borax, and three parts of oxyd of of nickel, also gave a clear light brown glass. Silex, phosphoric acid, and oxyd of nickel in the same proportions gave a honey-yellow glass but not quite clear.

Of Tungsten. Though this is not used it may be mentioned that with fluxes of phosphoric acid it gives a blue glass, but not when borax or alkalies are used.

Of Chrome. This metal which is the natural colouring matter of the ruby and emerald, would be a most valuable ingredient for the artificial gems if it could be procured with a tolerable ease. It has been found to give a fine red and also a most beautiful and exquisite green to glasses, but its great scarcity has prevented its frequent use. See CHROME.

Having thus generally described the colouring properties of the several metallic oxyds, some of the actual recipes for the different coloured glasses may be mentioned. These we shall chiefly give from M. Fontanieu, and from Neri and Kunckel, to which may be added the actual composition of a few of the beautiful antique coloured glasses, as found by the analysis of Klaproth. With regard to the recipes however, it may be added that there appears such enormous difference in the relative proportions of the metallic oxyds to the fluxes used, as either to give a suspicion of extreme inaccuracy or to shew that it must in most cases be determined by individual experience.

Of the Ruby red, Purple, Violet, &c. by Gold. Little can be added here to what has been said above under *Gold.* The particulars of the process have always been carefully kept secret by the successful artists, and from the frequent failures there can be no doubt that it is a very difficult process to manage. According to Kunckel and others who have succeeded, it appears that the colouring power of the *purple precipitate of Cassius,* or the mixed oxyds of gold and tin, is so great that one part will give a full rich body of colour to from 600 to 1000 or more of glass. The glass of antimony too seems an important addition. This ruby glass comes out of the fire colourless, but assumes its beautiful hue as it cools. It has been thought that the colour is also further brought out by exposure to smoke.

Of other Reds, Purples, and Violets. Some of these are composed of a colourless glass basis, such as one of the five before mentioned, with manganese either alone or with the purple precipitate of gold, or more commonly with the oxyd of cobalt. The colour given by manga-

nese being of a violet red, the cobalt will give it a more decided purple by adding its natural blue. It is impossible to pick out from the various recipes any other proportions, than that the oxyd of manganese will cover very fully about 100 times its weight of glass when used alone, and when employed with cobalt, 200 parts of glass will be highly coloured with one of manganese, and (for a purple) about one-third to two-fourths of zaffre.

Neri gives the following receipt for a glass to imitate the garnet, namely, 2 oz. of rock crystal, 6 oz. of minium, 16 grains of manganese, and 2 grains of zaffre. Kunckel gives for a violet red glass a common lead-glass basis with $\frac{1}{320}$ of manganese, mixed with nitre. Fontanieu gives for the imitation of the amethyst, 24 oz. of his glass, No. 5 (as already described), $\frac{1}{2}$ oz. of manganese, and 4 grains of purple precipitate of gold, together with $1\frac{1}{2}$ ounce of nitre. But the quantity of colouring matter here is so enormous that the vitreous basis should probably be 24 *pounds* instead of *ounces*.

A fine red has been mentioned to be procured from the oxyd of copper (with or without oxyd of iron) mixed with the due proportion of glass and with carbonaceous matter stirred in. For a full deep red the oxyd of iron should be three or four times as much as the copper, and in proportion as the latter predominates the colour approaches to carmine. The glass at first should appear when hot only of a faint greenish-yellow, and, when in full fusion, some tartar is stirred in, which instantly reddens the whole and causes it to swell prodigiously, after which it again subsides into a clear red glass, which should be worked off without delay. Probably charcoal would answer as well as tartar.

The antique red glass analyzed by Klaproth must probably have been made in the same way, that is by carbonizing a glass containing the oxyds of iron and copper. The colour was a lively copper-red, perfectly opake and bright at the point of fracture. The earthy and metallic parts of 400 grains, as given by analysis, were as follows:

Silex	142
Oxyd of lead	28
Oxyd of copper	15
Oxyd of iron	2
Alumine	5
Lime	3
	195

It is observable that this was opake, whereas the former mentioned glass is transparent. Klaproth conjectures that this antique glass was made not by any intentional proportion or selection of ingredients, but from the scoriæ of some copper ores.

Of Green Glasses. For these, which are intended to imitate the emerald when full-bodied, and the aqua-marine when light, there are many receipts.

Among others the following may be selected. Take 160 parts of any glass basis into which much lead enters, as the glass No. 1, 2, 3, or 5, mix it with 4 parts of the oxyd of copper made by simple calcination, and $\frac{1}{20}$ of a part of any oxyd of iron, and melt with a sufficient heat. In this as in all the other emerald colours a very small addition of iron seems highly useful to give somewhat of a richness of tint, and to take away the cold hue of the copper alone. For this reason too the rich yellow of the lead is of so much advantage.

Another is, 576 parts of the glass basis, 6 of the same oxyd of copper, and only $\frac{1}{144}$ of oxyd of iron. Another is, 200 parts of fine sand, 400 of minium, 8 of calcined verdigris, and 1 of oxyd of iron. The variation in these proportions is extreme.

Another method of composing the emerald-green is by a mixture of blue and yellow glass in due proportions. The yellow may be given by the oxyd of antimony, and the blue by cobalt. Fontanieu gives for this 120 parts of any of the glass bases, 1 of *mountain blue*, and $\frac{1}{12}$ of glass of antimony: or else 576 parts of the glass No. 2, 20 of glass of antimony, and 3 of oxyd of cobalt (not zaffre).

When the green has a sensible mixture of blue in the tint it forms a fine somewhat cold colour resembling the aqua-marine. This is produced in general by adding cobalt in some form or other to the materials for the green glass. For this the following receipts are given by Neri, Kunckel, and Fontanieu. Melt 300 parts of any fine crystal glass made without manganese, add thereto at intervals 6 parts of calcined copper or any similar preparation, and $\frac{1}{4}$ of a part of zaffre, stir the glass well while mixing, and then let them fuse quietly for some hours. No reasons appear however why the whole materials should not be mixed at first as in the usual mode. Another is, 300 parts of fine soda glass with 6 of calcined brass, melted together, stirred twice at long intervals, the heat being continued a long time, and finally suffered to remain in

quiet fusion for many hours before working. Another is, 256 parts of fine glass, and 150 of litharge or minium, first melted together and well mixed (or else any of the glass bases already mentioned that contain lead), to which is added 4 parts of calcined brass or of oxyd of copper made by calcination, and $\frac{1}{2}$ a part of zaffre. Another receipt for this colour is a mixture of yellow and blue, in such proportions that the blue shall prevail a little over the perfect green, the natural result of the mixture of blue and yellow. This is done by adding to 24 parts of the glass basis No. 1 or No. 3, 1-3 part of glass of antimony, and $\frac{1}{18}$ of a part of oxyd of cobalt.

According to Klaproth's analysis of a portion of an antique verdigris-green opake glass, the colour was formerly, as now, given by copper and a small portion of iron, the same in kind as those that composed the red glass above mentioned, and probably also the oxyds were not artificially mixed but were used as contained in a natural ore. Two hundred grains of this green glass or paste yielded

	grains
Of Silex	130
Oxyd of copper	20
Oxyd of lead	15
Oxyd of iron	7
Lime	13
Alumine	11
	196

Of Blue Glasses.—These glasses, which are intended to imitate the sapphire, are composed of a common basis and coloured with cobalt, but generally with the addition of a quantity of manganese, which by adding a violet tint gives a greater richness of body. When the manganese is in large proportion, the colour then is a rich violet blue or purple resembling the amethyst. There appears no agreement in the different receipts as to the relative proportions of manganese, only that the latter should be in less quantity than the cobalt when used in the dilute form of zaffre. These mixtures appear to be materially improved by being twice melted and poured into water and powdered between the first and second fusion. Among the several receipts the following may be given, namely, to 100 parts of a fine glass, without lead, add 1 part of zaffre and $\frac{1}{16}$ of a part of manganese. Another is 240 parts of glass frit, made with soda and sand only, 192 of minium, 2 of zaffre and one third of manganese melted twice and treated as above. Or a very fine blue glass may be made simply by the glass No. 5, with a necessary dose of oxyd of cobalt or zaffre.

Though blue glasses cannot be now made without cobalt, it is certain that iron in some mode of combination gives this colour in great perfection. It appears to be the natural colouring matter of the sapphire, lapis lazuli, and some other blue minerals, and is frequently produced accidentally in the scoriæ of iron ores. The art of colouring pastes and enamels blue with iron was certainly known to the antients but is now entirely lost. This is proved by the analysis of some of the antient blue enamels, in which no metallic matter but iron, with a small proportion of copper, can be detected. Whether the copper assists in the effect cannot be told. Klaproth analyzed an opake antient Roman enamel, the colour of which was sapphire blue verging towards that of smalt, and found the following ingredients.

	parts
Silex	163
Oxyd of iron	19
Oxyd of copper	1
Alumine	3
Lime	0.5
	186.5

Some of these plates of enamel were coloured equally throughout, others only to a certain depth on one surface, and the colour was given so uniformly that the plate had the appearance of two plates, one blue and the other colourless, adhering to each other.

Of Yellow Glasses.—The oxyds of lead, antimony, and silver are those which are used to give a yellow to imitate the varieties of the topaz, or the yellow diamond. M. Fontanieu gives the following proportions: 24 parts of the glass *No.* 1, or *No.* 3, and five eighths of a part of glass of antimony, or for the deeper coloured topaz, six eighths. For the imitation of the Brazilian Topaz he advises 192 parts of the glass *No.* 2, or *No.* 3, eight and one third parts of glass of antimony, and one ninth of a part of the purple precipitate of gold. An inferior yellow glass may be made by fusing simply 2 parts of fine sand or silex of any kind, with 7 parts of minium, but this is very soft. The delicate hue of the yellow diamond is imitated by adding to 576 parts of the glass *No.* 4, 25 parts of luna cornea, or ten parts of glass of antimony.

A colour varying in shade from brown to dingy smoke yellow, and thence to a fine transparent yellow, is given to com-

mon glass simply by adding to it when in soft fusion, any vegetable carbonaceous matter, part of which rises to the top and is burnt off, but a part also remains uniformly diffused through the glass, and gives it a fine yellow without impairing its transparency. No continuance of the fire will burn out this yellow colour altogether, after it has once lost its dingy smoked hue and acquired a clear yellow. Tartar has been commonly used for this purpose, but almost any vegetable inflammable substance not fluid, will probably do as well; the soft charcoal of the beech answers the same purpose. Manganese has been employed in the composition of this glass, but it appears to be of no use. Sometimes the carbonaceous matter is added to the glass frit when beginning to melt in the glass pots, at other times it is mixed with it before firing. A little nitre is found of use in clearing the colour and correcting the smoakiness, but too much of it will destroy the colour altogether. This glass swells much in the pot, when preparing, owing to the escape of part of the carbonaceous matter, especially when tartar is employed: but probably with quite dry and fresh burnt charcoal, previously heated strongly in close vessels for about an hour, no such effect would take place.

Of the Artificial Diamond.—Though no art has ever invented any vitreous composition which can be mistaken for the real cut diamond, by an eye at all practised, (unless by particular artifices in the setting, which are easily detected) yet some artists can prepare a very fine brilliant hard glass paste, which possesses great beauty, and a very considerable *water* or play of light, which more nearly imitates the diamond than all the common artificial gems. It will be sufficient here to add that M. Fontanieu recommends his glass *No.* 1, for this purpose. These glasses require a considerable length of time of strong fusion before they are brought to the state of the greatest clearness and brilliance.

Of Opake Glasses.—The materials which form the opake glasses are a common vitreous basis, as for the coloured glasses, and either an excessive dose of colouring metallic oxyd which shall give such a depth and body of colour as to produce opacity, or a substance which of itself gives an opake whiteness, to which any colour may be afterwards added if required. In general it is only the black glasses which are made opake by mere quantity of the same colour which, in smaller proportion, would be transparent; and the white glasses are made with a glass rendered opake by some addition which in any proportion impairs the transparency; and the blue, green, yellow, and other coloured opake glasses have the white glass for a basis, and are coloured in the same way as the transparent glasses.

White Glass.—The finest white glass is a vitreous base made opake by the oxyd of tin, and is then called *Enamel*, (which see).

But a very good white may be made at less expence by substituting for the oxyd of tin a pretty large quantity of bone-ash or phosphat of lime in very fine powder. It appears to be owing chiefly to the extreme infusibility of this earthy salt that the opacity is produced, so that in fact the glass thus made is a common vitrescent compound holding in intimate mixture a quantity of unvitrescible earth.

Neri's receipts for white glass are the following: mix together 60 parts of white sand, 40 of potash, and 10 of finely powdered bone-ash, and melt for the usual time of glass-making. The result is a glass, which when fully red-hot is transparent, but becomes milky and opake as soon as it cools. It does not appear certain whether this change is chiefly owing to a deception of sight which does not allow the degree of opacity to be distinguished when red hot, or whether the glass really becomes opake only when it cools, and then deposits the bone-ash by the effect of a kind of supersaturation by heat.

Another receipt is, 130 parts of sand or calcined flint, 70 of nitre, 12 of borax, 12 of tartar, 5 of arsenic, and 15 of bone-ash.

An imitation of the opal is made according to Fontanieu by mixing 576 parts of the glass *No.* 3, 10 of luna cornea, 2 of magnetic iron ore, and 26 of bone-ash.

Black Glass.—It is not easy to make a very full-bodied, perfectly opake, fine black glass. This is commonly made by manganese, and it has been found that one part of this oxyd will give a full body of opake black to about 20 of glass. A finer black used chiefly by the enamellers is made (as appears) by mixing together equal parts of manganese, zaffre, and scales of iron, and fusing one part of this mixed powder with 15 or twenty of any kind of glass.

For the other opake coloured glasses no more need be added than that they may be made in the same way as the transparent coloured glasses, substituting the opake white glass for the common vitreous base. These however are not much used in mass, or for any of the

common useful or ornamental purposes to which the transparent glasses are applied. The opake coloured enamels are composed on the same general principles, the base being the white enamel made with the oxyd of tin.

Glass, blowers lamp,
Glass, flint,
Glass, crystal,
Glass, crown,
Glass, green,
Glass, plate, or mirror glass,
Glass, coloured,
Glass, pastes,
Glass, purple,
Glass, yellow,
Glass, blue,
Glass, ruby,
Glass, violet,
Glass, opake, white and black.
See GLASS-MAKING.

Glass, gilding of. See *Gilding*.

Glass, silvering of. See *Foliating*, also, *Glass-Making*.

Glass, method of etching on. See *Engraving on Glass*.

GLASS OF BORAX is borax calcined till it loses its water of crystallization and flows into a very thin limpid glass. A moderate red heat is sufficient for the purpose. This becomes slightly opake by exposure to the air, in consequence of an incipient efflorescence.

GLASS-GALL, or *Sandiver*, is the scum of the glass-pots which arises during the vitrification of the frit. See GLASS-MAKING.

GLASSES (*Metallic*) are the oxyds, or sometimes the sulphuretted oxyds of the different metals vitrified by heat. Those of lead and antimony are the most familiar to Chemists.

GLAUBER'S SALT, called also *Sulphate of Soda, Vitriolated Natron, Sal Mirabile*, &c.

This salt is produced either by the direct combination of sulphuric acid and soda, or during certain processes of single or double decomposition. It is also found in mineral waters, and in the waters of the sea.

It was first discovered by Glauber, in 1658, in the residue of the distillation of common salt, and sulphuric acid, for procuring muriatic acid. This salt and Epsom salt, or sulphat of magnesia, were often confounded together, for some time after the first discovery of each, till the real nature of the latter was ascertained by Dr. Black.

Sulphat of soda is found native in a variety of places, and both solid and dissolved in natural waters, but on the whole, the quantity is but small. The native Glauber's salt, is found in Hungary, in the neighbourhood of salt lakes, and is described under this article. This salt is also contained in greater or less quantity, in almost every natural water that has any saline taste or quality, such as the Seltzer, Cheltenham, &c. and particularly in many of the hot saline springs, combined with carbonat of soda, of which the celebrated thermal waters of Carlsbad are striking instances, and are estimated by fair calculation to pour out annually, upwards of a million of pounds of this salt, along with other ingredients. Many brine springs also contain this salt, which remains in the mother water after the extraction of the common salt, and may then be obtained by evaporation and crystallization on cooling.

Glauber's salt, we have observed, is also procured in many processes of chemical manufacture, either as a residue, or an intermediate product in the preparation of soda. A good deal of it is obtained in manufacture, as a residue in the distillation of muriatic acid, from sulphuric acid and common salt, or of oxymuriatic acid from sulphuric acid, common salt, and manganese; or in the manufacture of sal ammoniac from sulphat of ammonia and common salt, which last furnishes the greater part of the Glauber's salt, imported into this country.

This salt is also obtained by the decomposition of muriat of soda by pyrites, and by gypsum, (as described under that article) and is the intermediate step in the manufacture of soda from common salt.

It is obtained in France by the combustion of the *tamarix gallica*. In the United States it is procured in abundance, especially in the eastern states, where salt is made from salt water, by the evaporation of the mother water, remaining after the formation of salt, from brine springs, licks, &c.

A manufactory was some years since established in this city, for the preparation of sal ammoniac, during which Glauber's salt was formed. Glauber's salt is composed of 58 water, 23·52 sulphuric acid, and 18·48 soda. Without stating the chemical properties of this salt, we shall only observe, that the conversion of the crystals into a white powder, called efflorescence, by exposure to the air, is nothing more than the separation of water, called the water of crystallization. Glauber's salt, thus effloresced, still retains its medicinal qualities. The best mode of administering it, is by dissolving it in hot lemonade.

GLAZING of Pottery. See POTTERY.

GLAZING, the art of fixing lights of glass in windows.

The cement, sometimes, though improperly called a glaze, which is used for connecting the pane to the window frame, is composed of whiting, and linseed oil, well tempered together, to which white lead is sometimes added.

From the frequent accidents, which happen to painters and glaziers, from the unsteadiness of their machines, and the consequent danger to which they are liable, when glazing or painting windows in the upper stories of a house, Mr. Davis has proposed the following invention to obviate this inconvenience.

Fig. 1, Represents the machine: the part *a* is similar to that used by glaziers, which is placed on the outside of the window. *b*, is an additional moving piece, which presses against the inside of the window frame, and is brought nearer to, or removed farther from it, by means of the male screw *c*, and its handle *d*.

Fig. 2. Shows the lower part of a window, and the manner in which the moving piece *b*, including a female screw, acts against the inside of the window frame.

Fig. 1.

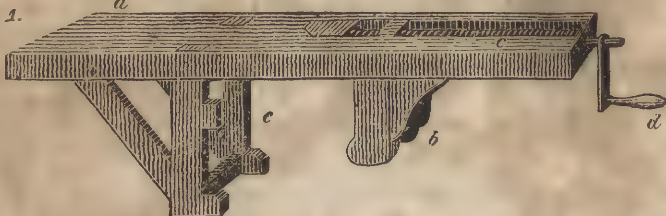


Fig. 2

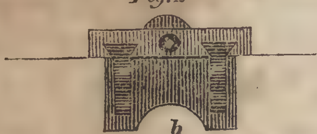


Fig. 3.

Fig. 3, Shews a cross bar, introduced in place of the moving piece last mentioned, which bar extends from one window side to the other, and explains how the machine may be used, where any injury might arise from screwing the moving piece in the centre of the recess of the window.

The general improvement consists in the use of a screw on that end of the frame which is within the house, and which keeps the machine steady and firm, instead of the two upright irons, which are put through holes made in the top plank of the machine, in the common mode, and which occasion the machine to be very unsteady in use, and liable to accident There are two blocks marked *e*, *e*, which may be occasionally put in, or taken out, according as the stone work under the window may require.

GOLD. Gold is a metallic substance of a pure yellow colour, remarkably ductile and malleable, of great specific gravity, and nearly as soft as tin. In fusibility it ranks between silver and copper; it is not oxydable by fusion in atmospheric air; nor is it acted on by any of the acids except the oxymuriatic and nitro-muriatic.

Ores of Gold—Gold is found only in one state, namely, the reguline, but is hardly ever pure, being alloyed more or less by silver, copper, tellurium, and a few other metals. When alloyed with silver or copper, or with both, it preserves its ductility, and is reckoned as native gold; when combined with tellurium, it entirely loses its discriminative external characters, and in this state is generally classed among the ores of tellurium. For the convenience, however, of the reader, we shall describe this latter substance both here, and when we come to treat of tellurium, trusting that a little repetition will be excused on this account.

Native Gold—Its colour when pure, or nearly so, is a bright, somewhat orange yellow; in proportion as it is alloyed with silver, it inclines to a pale brass yellow; when combined, as is supposed with platina, it passes from brass-yellow to steel-grey. It occurs in detached lumps and

grains, disseminated, superficial, reticulated, dendritical, capillary, cellular and scaly, as a snuff-coloured powder, and sometimes, though rarely, crystallized in small cubes, regular octahedrons and rhomboidal dodecahedrons. The crystals are for the most part minute and very irregular. The surface of the crystals is smooth and brilliant; of the other varieties, the lustre is faintly shining and glimmering; when cut with a knife it displays a bright and perfectly metallic lustre. Its fracture is hackly. It is very soft, perfectly ductile and flexible, but not elastic. Its specific gravity varies according to its purity from about 17. to 19.

Before the blow-pipe it runs into a globule without emitting any vapour.

Native gold is rather a rare mineral, and is by no means the principal source of this valuable metal. It occurs in veins or dispersed through the substance of primitive mountains, especially argillaceous schistus, and clay porphyry, and is accompanied by quartz, feltspar, calcareous and heavy spars, pyrites, red and vitreous silver ore, galena, &c. The richest mines of native gold are found in Brazil, Peru, and Mexico; some of the African, Sumatran, and Japanese gold, is also procured from a similar source; the mine of Beresof in the Uralian mountains, and some of the Hungarian and Transylvanian mines likewise yield native gold, though in small quantities.

But by far the largest proportion of native gold is found accidentally dispersed through certain alluvial strata. That this, is not its natural situation is manifest from its occurring here only in rounded and flattened masses, from microscopical spangles to pieces three or four pounds in weight, all of which exhibit decidedly the effects of friction. It is from the sands of certain rivers that this stream gold as it may be called, has been chiefly procured; and it was naturally thought that its original bed was at the mountainous sources of these streams, whence it was detached by the force of the torrents, and deposited in the lower and quieter part of the river. In some instances this is no doubt the case, but in most others the transportation of the gold appears to have taken place at a period anterior to the formation of our present rivers. Where gold is found in the bed of an actual torrent at no great distance from its source and in a mountainous country; where, too the gold is confined within the present or probable former boundaries of the stream (as is particularly the case with that recently found near Cronebane in the county of Wicklow in Ireland) it may be considered as indicating the presence of gold, either dispersed or in a regular mine in the adjoining rocks. But on the other hand, when gold is found in the bed of a river at a considerable distance from its source; if the surrounding country is plain or nearly so; if the auriferous sand forms a stratum extending to a considerable distance beyond the river; then it is probable that the river has merely cut through a previous alluvial stratum holding gold, and that to endeavour to find the mine whence this metal originated by searching the rocks towards the source of the stream, is mere loss of time.

A considerable portion of the stream gold seems to have been contained in auriferous pyrites, for almost all the sands from which this metal is extracted are highly ferruginous, and of a deep blackish-brown colour: the gold itself is mostly of a pale yellow, and is considerably alloyed with silver. The Peruvian, Mexican, and Brazilian rivers, are many of them extremely rich in gold, as are likewise several of the streams on the western coast of Africa: in Europe, the Danube, the Rhine and the Rhone, afford small quantities of this metal, and from several other of the lesser rivers it has been extracted rather for curiosity than profit: the streams of Hungary and Transylvania, under the patient management of the Zigueners or Gipseys, yield a greater quantity of gold than the rest of the European rivers, yet hardly sufficient to afford a very scanty maintenance to the labourers. Of the alluvial strata yielding gold, none has ever been found comparable in richness to the plain of Cineguilla in the province of Sonora, on the Eastern shore of the Californian gulf: this plain is about fourteen leagues in extent, and contains large lumps of gold irregularly dispersed through it at the depth of about 14 inches.

Besides the gold found in Cabarrus county, North Carolina, which furnished the mint previous to the year 1805, with $11,000 gold coin—this metal has also been discovered in Virginia. A lump of gold ore found near the falls of Rappahannock river, yielded 17 dwt. of gold. Small lumps of gold to the value of several hundred dollars have been found in the county of Buckingham, between James and Appomatox rivers, in the same state.

Graphic Gold. Its colour is tin white with a shade of brass-yellow: it occurs

crystallized in small flattened prisms with four or six sides, and terminated by tetrahedral pyramids. It is soft, brittle, and may easily be cut with a knife.

According to the analysis of Klaproth, it consists of

Tellurium . .	60
Gold	30
Silver	10
	100

It has hitherto been found only at Offenbanya in Transylvania, in thin layers, upon grey quartz, in clay porphyry, and is accompanied by iron-pyrites, grey-copper, blende, and occasionally native gold.

White Gold Ore.—Its colour is silver-white, passing into brass-yellow: it occurs disseminated, and in small imbedded prismatic crystals. Externally it has a bright shining metallic lustre. It is soft, and somewhat ductile. Sp. gr. 10.6.

It consists according to Klaproth, of

Tellurium . .	44.75
Gold	26.75
Lead	19.5
Silver	8.5
Sulphur . . .	0.5
	100.00

It has hitherto been found only at Nagy-ag, in Transylvania, where it occurs in a gangue of quartz and brown spar, accompanied by blende, grey-copper, and copper-pyrites.

Black Gold Ore.—Its colour varies from lead-grey to iron-black: it is seldom found in mass, being generally disseminated in the form of small scales, or long hexagonal plates, either single or accumulated on each other. It has a moderately shining metallic lustre. It stains the fingers a little, is somewhat flexible, and very soft. Sp. gr. 8.9.

It consists according to Klaproth, of

Tellurium . .	32.2
Lead	54.
Gold	9.
Silver	0.5
Copper . . .	1.3
Sulphur . . .	3.
	100 0

It has been found as yet only at Nagy-ag in Transylvania, in a gangue of red manganese, brown spar, and quartz, accompanied by galena, iron pyrites, blende, plumose antimony, and grey copper ore.

Sp. 5. Auriferous Pyrites.

The bronze-yellow Iron Pyrites in mass or in striated cubes, and the hepatic pyrites when occurring in veins in primitive mountains, are sometimes found to contain a sufficient quantity of pure gold, or of gold alloyed with silver, to be well worth the trouble of extracting by methods that will be described hereafter. It was formerly supposed that the gold as well as the iron in this ore, was mineralized by the sulphur; the experiments of Bergman however pretty clearly shew that this is a mistake, and that the gold in small scales is merely interposed between the laminæ of the pyrites. A considerable proportion of the American gold, and by far the largest portion of the Hungarian gold, is obtained from this ore. The produce of the Hungarian pyrites is very various, sometimes not exceeding a few grains of gold in the quintal of ore, but in the celebrated mine named Maria of Loretto, near Zalathna, in Transylvania, is a vein of auriferous pyrites, that occasionally yields as much as 450 ounces of gold in the quintal.

Sp. 6. Auriferous Galena.

The native sulphuret of lead commonly called galena, almost always contains a little silver, which not unfrequently is sufficiently abundant to be worth the trouble of extracting.

The galena of Hungary occasionally holds not only silver but gold, and is accordingly worked as one of the ores of this precious metal: the galena of Boicza yields an ounce and a half in the quintal of an alloy, of which 31 parts are silver and 1 of gold.

Reduction of Ores.—The richest gold mines concerning the working of which we have any very particular description are those of Hungary: the method of proceeding therefore in these establishments shall be first mentioned. The high commercial value of gold compared with that of any other metal depends in a considerable degree on its rarity, hence even the most profitable veins of gold are of trifling magnitude, and will pay very well to the miner though mixed very intimately with so large a proportion of stony gangue and other impurities as would render it impossible to work with advantage any other metal similarly circumstanced.

In the Hungarian mines the attention of the miner is not confined to the strings of ore, but the whole contents of the vein are usually extracted. It is raised for the most part, in large masses to the surface, and is then distributed to the workmen, who break it first with large hammers and afterwards with smaller ones, till it is re-

duced to pieces of the size of a walnut or less. During this process each piece is attentively examined and arranged according to its value: the native gold even to the smallest visible grain is separated as accurately as possible from the quartz in which it is chiefly imbedded, and put by itself; the auriferous galena and pyrites are also thrown into separate heaps. The small splinters detached during this process, as well as the sand and mud of the mine are also collected, washed and sifted, and arranged according to their fineness and apparent richness. The portion rejected in this first examination is afterwards re-examined by boys, whose time is of little value, and who pick out nearly the whole of what has been overlooked by the men, and sort it in the manner just mentioned.

The native gold with its adhering matrix is again broken by hand into still smaller pieces, by which an additional quantity of impurities and stony matter is got rid of: it is then put into a kind of wooden box floored with cast iron plates, and reduced to a fine powder by the action of two or more heavy spars of oak, shod with iron and worked alternately in the manner of a common stamping mill. This powder, or flour as it is called, being now removed into a convenient vessel like a large bason, is mixed with a sufficient quantity of salt and water to render it damp, after which a workman takes a thin porous leather bag, puts a quantity of mercury into it, and by a continued regular pressure forces the mercury in minute drops like dew through the leather: in this minutely divided state it falls upon the pulverized ore, and is immediately kneaded up with it till the requisite quantity (depending in great measure on the proportion of gold) has been added. This part of the process being compleated, the mixture is rubbed together by means of a wooden pestle for some time to expedite the incorporation of the mercury and gold, and is afterwards heated in a proper vessel to about the temperature of boiling water for three or four days: finally, the mixture is washed very carefully by small parcels at a time, the earthy particles are carried off by the water, and there remains behind only the mercury combined with the gold into an amalgam. Part of the mercury is then separated by pressure in a leathern bag, and the rest is driven off by distillation, leaving behind only the gold and the silver with which it may happen to be alloyed. (For a fuller account of this process see SILVER.)

Such is the simple method by which the native gold of the ore is extracted; a much more complicated process however is required to separate that portion of the metal which is dispersed invisibly in the pyrites, ochre, galena, and other metallic substances, as well as the stony parts of the gangue. These in the sorting already described, are separated not only according to their apparent richness, but, what is of more importance, are also arranged according to their hardness. This being compleated they are transferred to the stamping mill.

The principal parts of a stamping mill are the following: 1. The coffers or cisterns, usually two in number, in which the ore is pulverized, and through which a stream of water that may be increased or diminished at pleasure, continually passes. 2. The stampers or vertical beams shod with iron. 3. The axle, fixed horizontally, and working at one end in a pivot and rivetted at the other into the centre of a large water wheel. Hence the mode of its action is evident: a stream of water falling upon the wheel turns it round, and at the same time the axle to which it is attached: the cogs fastened upon the axle raise alternately the stampers to a given height, and then let them fall upon the ore that is placed in the coffers, which in proportion as it is sufficiently comminuted, is carried by the water that is continually flowing through, out at the sides of the coffer, into the labyrinths where the stony and metallic contents of the ore are deposited nearer to, or further from the discharging aperture, according to their respective specific gravity.

The coffer is a rectangular hole sunk below the level of the ground, and both floored and lined with strong double oak planking: it is about four feet deep, five in length, and two feet or less in width. The stampers are five in number, and are strong oaken beams terminated with iron, and weighing about 200 pounds each; they are placed side by side, about two inches and a half distant from each other. When any ore is to be pounded, the first thing is to cover the bottom of the coffer with a close-set flooring or pavement, composed of large pieces of the hardest and poorest part of the vein, such a floor being found by experience to be much better on many accounts than an iron one. The thickness of this floor is inversely according to the hardness of the ore to be pounded; it being manifest that the higher this is the smaller will be the space through which the stampers have to fall, and therefore the less will be their momentum: care must however at all times

be taken, that the part of the floor immediately beneath the middle stamper, is about two inches lower than that below the stamper on each side of the middle one, and that this again, is about an inch lower than that beneath the two outermost stampers. The coffer being thus prepared, the stampers are set in motion by the water wheel, a small stream is allowed to flow into the coffer, and the ore is thrown in just below the middle stamper, by a careful workman, or supplied in the proper quantity by a hopper: the ore being comminuted by this stamper, is gradually delivered to the next on each side, where it is still further pulverized, and from which it is passed on to the two outermost stampers, by which it is at length reduced to grains of such fineness, as to be for a time suspended in the water, and carried by it through one or other of the apertures which are at each end of the coffer.

Much care is required, especially in stamping the ores of gold and silver, in the first place that no pieces be subjected to the process that can economically be separated by hand from the gangue, for even when it is the most skilfully conducted, a very notable proportion will be lost; and secondly, that the ore be pounded either fine, or coarse, or be subjected to greater or less force according as circumstances may require. If the ore is principally native gold dispersed in very minute particles through quartz or hornstone, it will be impossible to separate the whole or nearly the whole of the metal, except it is reduced to exceedingly fine powder, and this may be safely done both because the difference in specific gravity between the two ingredients of the ore is very great, and also because the quartz if reduced to particles ever so minute, does not at all clot and adhere to the gold. In this case therefore the floor of the coffer may be set as low as possible, to give the stampers their greatest momentum, and only a very small stream of water may be let in, that the current passing out of the coffer may carry with it only the smallest particles. It often however happens that the gold is disseminated in a very ochery and highly indurated clay, or in calcareous spar, and in this case there is only a choice of difficulties: if the ore is not extremely comminuted much of the metal will be kept in the earthy matrix, but if on the other hand the stamping is continued too long, the whole will be reduced to a fluid mud, which will prevent the thin laminæ of gold from subsiding; and long practice and accurate judgment are required to manage the process, so that the greatest quantity of gold shall be obtained. Sometimes, as at Kremnitz, the gangue consists partly of quartz and in part of indurated clay; in this case the most approved practice is, to raise the floor of the coffer to within about eighteen inches of the top, to put a moderate quantity of ore at once under the middle stamper, and to let on, in the beginning of the process a full stream of water; by this the clay as being the softest is battered to pieces, and carried off by the water before the quartz is sufficiently comminuted to be washed out in any considerable proportion with it; the stream of water is then slackened, and the quartz is reduced to sand of the requisite fineness. There are few things that so much facilitate the washing subsequent to stamping, and upon which the product of metal so much depends, as the reduction of the gangue to grains of an uniform size; this is brought about by being careful that the ore when first put into the coffer, falls under the middle stamper, and also by regulating the velocity of the water wheel; if the motion of the stampers is too slow, the only bad effect is loss of time; but when their action is too much accelerated, the water is dashed about and carries with it to the opening at the end of the coffer pieces of the ore that are not half ground, as well as those that have gone through the whole process; this fault is obvious not only from the difference in size between the grains, but those which have not been sufficiently pounded will be of a flat angular figure, and in consequence will remain behind with the metal in the subsequent washing, instead of being carried off the tables together with the rest.

When by the process of stamping, the ore is reduced to particles of sufficient fineness to be carried out of the coffer by the force of the water, it passes into shallow channels or troughs of various dimensions, constructed either of wood or stone, and communicating at their extremities with each other; the whole series is called a labyrinth. In these channels the various parts of the ore are deposited, according to their respective specific gravities; the heaviest particles being detained in the first, and the lightest subsiding in the last and lowest. Each of these channels is grooved at its lower extremity, to admit of its being closed at pleasure by pieces of wood about an inch in height, which slide down upon each other like the planks in a Chinese lock. It is obvious that the accuracy by which the heavy particles can thus be separated

from the lighter ones, will be much modified by varying the rapidity of the stream through these channels, so that at its outset the stream shall be swift and its velocity shall gradually decrease as it passes successively from one channel into another. This is effected by diminishing the slope and augmenting the width and length of the channels. Thus that which receives the water immediately from the coffer of the stamping mill is about four yards long, nine inches in depth and breadth, and has an inclination of two and a half or three inches; the second is about five yards long, twelve inches in depth and breadth, and has one inch of inclination: the third and fourth are six yards long, with a depth and breadth equal to the former, and an inclination of half an inch; the fifth is seven yards long, fourteen inches in breadth, twelve in depth, and is not inclined at all; the sixth is from eight to ten yards long, sixteen inches in breadth, twelve in depth, and like the former is intirely level. When these channels are about to be used a slider about an inch high is put into the groove at the extremity of each, to prevent the grains which are deposited from being rolled out and washed away by the force of the water: when the deposit nearly attains the level of the top of the slider, a second is put in, and thus the process goes on till the channels are almost filled. The water from the coffer is now turned off into another labyrinth, and the contents of the former are taken out, care being taken not to mix what has subsided in any one channel with what has been deposited in the others. By means of the foregoing process, if carefully conducted, the metallic contents of the ore will be separated in a considerable degree from the lighter stony particles: every thing however depends upon the skill and accuracy of the manipulation, more especially where gold ores are thus treated, because in this case the proportion of gangue to the ore is greater than in any other, hence even a moderate degree of carelessness or of imperfection in the apparatus, will occasion a loss of full one fourth of the gold.

The first operation of washing, however carefully conducted, is by no means entirely adequate to the entire separation of the sand from the ore, it is therefore a second time washed on what are called tables. These are long planes of wood, considerably inclined (more or less according to circumstances) and crossed here and there at regular distances by narrow shallow grooves. To the upper extremity of the table is fastened a long wicker basket, or a perforated wooden trough, which is filled with washed ore; a little stream of water is then admitted, which passing between the twigs of the basket trickles down upon the table, carrying with it particles of the ore, which are either carried entirely off the table by the impulse of the water, or are deposited in the grooves according to their specific gravity, the heaviest particles being stopped the soonest. By this method the auriferous ores of iron and copper pyrites, galena, blende, &c. are sufficiently separated from the quartz and other stony matter to be fit for the smelting furnace; but the ores of native gold generally undergo a third washing, which is performed on small quantities at a time, in a wooden vessel called by English miners a buddle; its shape somewhat resembles that of a common fire-shovel without a handle, only the sides are more elevated in proportion, and it is furnished with two ears to hold it by. The ore being put in the vessel is gently immersed in water, and a circular motion is communicated to it by a peculiar slight of hand not to be described by words, by means of which the lighter particles are by degrees thrown out of the buddle into the water, hardly any thing but the gold remaining behind, which is then either amalgamated or directly fused in an earthen crucible with the addition of a little nitre.

The gold that is found in alluvial soil or in the sands of rivers, is obtained in precisely the same way, except that it is not necessary to pass it through the stamping mill previous to washing.

The proper auriferous ores being lighter than gold, and their contents being rarely of sufficient value to admit of that accuracy in washing to which native gold is subjected, are always found after they come off the washing tables to be mixed with a very considerable proportion of stony matter. If the metallic part consists of pyrites, as is usually the case, it is advisable previous to fusion to give it a moderate roasting in order to drive off the greater part of the sulphur. The extent to which this process ought to be carried depends in some degree on the quantity and refractoriness of the stony part of the ore, for the sulphur in the subsequent fusion acting the part of a flux, it is obvious that the cleaner the ore is, the more perfectly may it be roasted. This being finished, the ore is accurately mingled with a little quick-lime by way of flux, and with galena proportioned to the quantity of gold and silver that the pyrites contains according to the result of a previous assay. The mixture being now

placed in a reverberatory furnace is made red hot, and as soon as it begins to clot together is stirred up from time to time and kept at a temperature inadequate to its fusion till part of the sulphur is driven off; this being effected the fire is increased, the whole is brought to a state of thin fusion and then let out in the usual way into a mould of sand. During the fusion the iron, on account of its powerful affinity for sulphur, resumes the portion of which it had been deprived by the previous roasting, by decomposing the sulphurets of lead and copper with which it is mixed, in consequence of which these metals by their specific gravity fall in drops through the vitreous ferruginous scoria, carrying with them the gold and silver, and unite at the bottom into a dense metallic mass. Hence the *pig* that is formed in the mould of sand is found to consist of two parts adhering to each other, but easily separable by a hammer; the uppermost and by far the largest portion is more or less cellular and consists of scoria, beneath which is a black heavy compact mass containing the gold and silver, together with lead, copper, some sulphur and iron. It is now broken into small pieces and roasted and fused once or twice more till all the sulphur and other impurities are got rid of, nothing remaining but the gold, silver, lead and copper.

Refining.—Although the refining of gold generally relates to the separation of this metal from silver and copper, these being the principal substances with which it is alloyed, yet it may with much propriety be considered as including all the methods of purifying gold from every other metallic admixture. In this sense the term is used on the present occasion, and we shall proceed to treat of it accordingly.

Separation of Gold from Lead and other metals by Cupellation.—The most economical method, and the only one commonly practised, of separating gold from lead is by a process called cupellation in the small way, and testing when practised on a large scale. The particular precautions requisite in cupellation are described under the article Assay, as the method of testing is under Silver. All that is necessary to be stated here therefore, is merely the rationale of the process. The cupel or test is a porous infusible earthy mass, with a shallow concavity at the top for the reception of the metal: this being placed in a furnace so as not to be in contact with the burning fuel, and a current of air at the same time passing over the surface of the test, the metal is brought almost to a state of ebullition. At this temperature the lead is separated from the gold in the form of a vitreous oxyd, which sinking into the pores of the test leaves the gold behind nearly in a state of purity, this latter metal being incapable of oxydation at any temperature by simple exposure to heat and air.

Not only lead may thus be separated from gold, but its effect as a flux in scorifying and carrying down most of the imperfect metals is so great that by means of the process of cupellation with lead, repeated according to the proportion of the alloy and its affinity to the gold, these may also be got rid of nearly to the last atom. And this method is actually practised where the proportion of alloy is but small; when however it exceeds a certain ratio it is more economical to have recourse to the other methods detailed in this section.

It is to be observed however that when fine or pure gold is thus cupelled with lead, it always retains a small portion of this metal, which however minute is sufficient to impair both its colour and ductility. If besides lead the mixture contains copper to the amount of one twenty-fourth of the gold, the whole of the lead will be separated but hardly any of the copper. If in addition to the above ingredients the alloy contains a somewhat greater proportion of silver than it does of copper, this latter is separated by cupellation and a little of the lead remains: but if the amount of silver is equal to, or exceeds that of the gold, both the copper and lead may be completely worked off, the gold and silver remaining behind. Hence it is, that the refiners in separating the base metals from gold by cupellation, always add to the mixture a considerable proportion of silver.

Cupellation with lead alone does not succeed when gold is alloyed with tin: in this case the tin with part of the lead forms a very spungy and refractory oxyd, which floats upon the surface of the melted metal and retains a part of the gold. This difficulty however is ingeniously obviated by the addition of some iron filings, which combine with the tin into an alloy that may be scorified by lead without any great trouble.

Separation of Gold from Antimony.—If the proportion of antimony exceeds that of the gold, the alloy, which will be very brittle, must be reduced to small pieces and mixed with about a fourth of its weight of sulphur and fused in a covered earthen crucible. When the fusion is compleat it must be poured into a melting cone, previously heated and greased,

and when cool will be found to consist of two parts readily separable from each other; the upper will be sulphuret of antimony holding a very little gold; the lower will be the rest of the gold still combined with regulus of antimony. The greater part of the antimony being thus separated, the rest may be got rid of, by melting the alloy at a high heat and directing a stream of air from a pair of bellows into a crucible containing it, by which the antimony is oxydated and volatilized in the form of a white vapour. Shortly after this appearance has ceased and the gold has acquired a clear bright green colour, it is to be poured out, and being then remelted in a smaller crucible, together with some nitre, the last portions of antimony, if any should happen to remain, will be compleatly oxydated and separated from the gold. The small quantity of gold detained in the sulphuret of antimony may be procured by bringing it into thin fusion and then precipitating part of the antimony by the addition of about a fifth of its weight of iron filings: the gold will fall down together with the antimony, and may be separated in the way just described.

Separation of Gold from Silver and the imperfect metals by Sulphuret of Antimony.—By this method all the common imperfect metals except zinc may be separated from gold: for in the first place, gold is incapable of combining with sulphur, and in the next place most of the other metals have a stronger affinity for sulphur than antimony has. It is obvious therefore that if to an alloy of gold and copper, for example, be added some sulphuret of antimony, the copper will become sulphuretted at the expence of the antimony, which in its turn will combine with the gold.

Earthenware crucibles are the only ones that can be employed where sulphuretted metals are concerned, but if these are used without any preparation they are extremely liable to crack and be corroded. The black-lead crucibles are fitter for this purpose than the common kind, but these last when prepared according to the method recommended by Scheffer are more durable and convenient than those of black-lead. The preparation is very simple: take a well-burnt crucible and soak it for two or three days in linseed oil, then clear away the oil to such a degree as that some finely pulverized glass of borax being dusted over the inner surface may just adhere, let it then be set by in a dry place for two or three weeks and it is ready for use. In such a crucible above two hundred fusions, according to Scheffer, may be performed in safety.

The gold alloy being melted in the crucible, there is thrown in, at two or three different times, about twice its weight of coarsely pulverized sulphuret of antimony: at each addition the mixture froths and swells up so that the crucible must be large in proportion to the quantity contained; and especial care must be taken to prevent any pieces of charcoal from falling in, as this would infallibly cause the melted matter to run over. If the purity of the gold as previously found by the assay is less than 16 carats, the crude antimony before it is added should be melted with about a fourth of its weight of common sulphur, by which too large an addition of antimony to the gold is avoided. As soon as the mixture sparkles on the surface and is perfectly fluid, it must be poured into a melting cone previously heated and greased, and a tremulous motion by continued slight blows must be communicated to the mould to promote the settling of the precious metal. When the matter in the cone is become solid, it may easily be got out by inverting the cone and giving it a few blows in this situation: it will be found to consist of a reguline mass of gold and antimony covered by a scoria composed of the former alloy of the gold united to the sulphur of the antimony. The gold however still retains a little of its alloy, and in consequence requires to be again melted a second, or even a third or fourth time, with the same quantity of sulphuret of antimony. From these last fusions the gold receives only a slight addition of antimony, as this metal unites with it only in proportion as it is deprived of its own sulphur by the small portion of alloy yet remaining in the gold. These processes being duly performed, the antimony is to be separated in the manner already described and the gold remains perfectly pure. Where the proportion of antimony is considerable, it is likely that its separation from the gold, which is usually a tedious business, might be expedited by a judicious fusion with sulphur, which converting part of the antimony into sulphuret would cause its spontaneous separation from the rest. The metals from which gold may be purified with particular advantage by means of antimony are iron, copper, tin, lead and silver.

Separation of a small quantity of Gold from a large quantity of Copper.—In old gilt copper wire, button-maker's clippings, and auriferous copper from Japan and other places, although the propor-

tion of precious metal is too great to be neglected, yet it is by no means sufficiently large to admit of separation by the cupel or by sulphuret of antimony. The process of eliquation, or of fusing the copper with a large quantity of lead, and then exposing the mixture to a heat capable of melting out this latter while the former still continues solid, although practised with success in the separation of silver from copper has been repeatedly attempted in vain for the extraction of gold. But the following method, first published by Alonzo Barba, may on this occasion be resorted to with good effect.

Let the copper be first melted and granulated by being poured into water; then heat the metal red-hot in a crucible, and project on it at different times portions of common sulphur till the whole becomes black and brittle; then reduce it in a mortar or by any other convenient way to a fine powder and subject it to amalgamation in the same manner as the proper ores of gold; the mercury will dissolve out the whole of the latter metal without exerting the least action on the sulphuret of copper, which may afterwards be brought to the malleable metallic state by roasting fusion, as already described in the article copper.

There is another method however still more advantageous which may be employed for this purpose. Equal weights of sulphur and litharge are to be mixed together and combined by hasty fusion into a black sparkling mass: the gold holding copper being then melted, the sulphuretted lead is thrown in by small quantities at a time till its amount nearly equals that of the copper. All the ingredients, in consequence of the lead being in the state of oxyd, unite together into an uniform mass. When the whole is in compleat fusion some finely pulverized charcoal is added at two or three several times, being carefully stirred in, with a piece of strong copper wire. The charcoal immediately deoxygenates the lead, which sinking to the bottom in its metallic form, draws with it the whole of the gold also, leaving a scoria of sulphuretted copper floating on its surface. The gold is afterwards freed from the lead by cupellation.

This same process might no doubt be applied to the separation of gold from iron.

Separation of gold from Silver.—If the proportion of gold is very small, the best way of separating it from the silver is by means of sulphur. For this purpose the alloy is melted, and granulated by being poured into cold water kept constantly in agitation by a wicker brush or rod. Of the granulated metal from an eighth to a fifth is reserved, and the rest is well mingled with about an eighth of its weight of pulverized sulphur, which readily adheres to the moist grains. This mixture is put into a covered crucible and gently heated for some time, that the metal may be thoroughly penetrated by the sulphur: when this is effected, the fire is to be raised, and the mass brought into fusion. In these circumstances it might be thought the gold, on account of its great specific gravity, having also no affinity with sulphuretted silver, would fall in drops to the bottom of the crucible, and there unite into a mass by itself. This however is not the case; the sulphuretted silver forms a tough viscous fluid, in consequence of which the minute grains of gold are prevented from subsiding. When therefore the mass has been in full fusion about an hour, so that the sulphur is compleatly united with the silver, and any accidental excess of it has burnt off, one third of the reserved silver in grains is added, and as soon as melted is stirred with a wooden rod in order to mix it very accurately with the other materials and thus bring it in contact with the gold, with which it immediately combines. After another hour of fusion, a like quantity of grained silver is again added, and an hour after this the remaining third. The crucible is now kept carefully covered, and at a pretty high temperature for about three hours, its contents being well stirred up from the bottom at least once every half hour. At the end of this time the surface of the mass instead of exhibiting the dark brown colour of sulphuretted silver, will have become whitish in consequence of the escape of part of the sulphur, and some bright white drops of melted silver of the size of peas will also appear. The matter must now be poured into a greased cone, with the usual precautions, and when cold will be found to consist of a mass of sulphuretted silver, resting upon a white metallic button about equal in weight to the added silver, and containing the whole of the gold that was at first mixed with the entire mass. If the sulphuretted silver retains any gold, this may be separated by fusion in an open crucible: part of the sulphur burns off, and a corresponding quantity of silver is reduced to the metallic state: this being mixed with the rest by being carefully and repeatedly stirred with a piece of stick will attract the whole of the gold remaining in the

silver that is still sulphuretted, and being poured into a cone will collect in one mass at the bottom.

The gold-holding silver collected in these two operations being melted and granulated, is subjected to one or more repetitions of the same process, till the silver that is left contains a sufficient quantity of gold to make it worth while to proceed to parting by aqua fortis. It is possible indeed, to separate nearly the whole of the silver by means of sulphur; but, when the silver comes to be rich in gold, the sulphuretted silver always takes up a portion of it which is not separable again entirely without repeated fusions; so that, when the gold amounts to a twentieth of the silver, it is scarcely advantageous to attempt a further purification by means of sulphur.

It appears from various experiments that the affinity of gold for copper, and of silver for lead is considerably greater than that which subsists between gold and silver, and upon this is founded a very ingenious and economical method of separating the gold from old gilt lace or silver wire, which has been practised in Saxony to a considerable extent. The metal being granulated, one sixteenth of it is mixed with half its weight of litharge, and one eighth of sandiver, and is named the precipitating mixture: the next is mingled with an eighth of pulverized sulphur, and is brought into fusion in the same manner as already described. When the fusion is compleat, which is known by a kind of flashing at its surface, half of the precipitating mixture is added at three different times, with an interval of about five minutes between each, and the fusion is then continued about ten minutes longer. Part of the sulphuretted silver is then laded out with a small crucible made red hot, and the remainder being poured into a melting cone, there subsides to the bottom a quantity of metallic silver combined with the greater part of the gold. The sulphuretted silver being again melted, the remainder of the precipitating mixture is added in the same manner as at first, and a second portion of gold holding silver is thus procured. The sulphuret still retains a small quantity of gold, in consequence of which it is a third time fused, and a precipitating mixture, equal in weight to the preceding, but composed of an alloy of equal parts of copper and lead, is added, by which a third precipitate of gold-holding silver is thrown down, and the sulphuret has now lost all its gold.

The several metallic masses thus procured are melted with an eighth part of lead, then granulated, and subjected to exactly the same treatment by sulphur, and the precipitating mixtures as at first. The silver thus obtained being now very rich in gold is granulated, mixed with a sixteenth of sulphur, and kept in fusion for about half an hour, without the addition of any precipitant: being poured into a cone, the sulphuret is separated from the metal, and this last is treated twice or thrice more with sulphur in the same manner. The metallic button which now begins to exhibit a yellow colour, is melted with a sixteenth of copper, then granulated and mixed with a sixteenth of sulphur: this mixture being first gently heated in a covered crucible, and then fused for about a quarter of an hour, is poured into a cone, at the bottom of which the gold is found, of a brass colour, and about eighteen carats fine. Its purification is then compleated by sulphuret of antimony, as we have already described.

When gold and silver are alloyed together in such proportions that the former of these metals is not much less than a sixteenth, nor greater than a fourth of the whole mass, the usual method of separating them is by means of nitrous acid, or aquafortis. The operation is technically called *parting*, and differs from the process described under the same name in the ASSAY, only in being performed in larger quantities, and without some of those nice manipulations which are absolutely necessary to the accuracy of an assay.

Silver is readily dissolved in nitrous acid, while gold in ordinary cases, is not at all attacked by this menstruum: in consequence of which when this latter metal amounts to one third of the mass, it combines with and protects by its own insolubility a portion of the silver from the action of the acid: hence, the necessity of avoiding too large a proportion of gold in the alloy. On the other hand, as the expence of nitrous acid is considerable, it is requisite that the silver should be rich in gold, to render this process which is very convenient on many accounts, also economical. The refiner therefore, will be careful not to use pure silver, but such as contains a little gold, in lowering the fineness of such as is too rich in gold to be successfully parted by itself, and by every other contrivance will study to employ no more acid than is absolutely necessary.

A proper selection being made of poor and rich ingots of mixed metal, the whole is melted in an iron crucible, and well mixed by repeated stirring: it is then laded out by a clean iron ladle, and granulated by being poured into cold water

The glasses in which the parting is performed, thence called parting glasses, are nearly of the figure of a truncated cone, with a rounded bottom, about twelve inches high, and seven inches wide at the lower extremity; especial care must be taken in the choice of them, that they are without flaws of any kind, well annealed, and of an equal thickness throughout. Each glass is to be charged with about forty ounces of metal, to which is added nitrous acid, already half saturated with silver, in such quantity as to stand two or three fingers' breadth above the surface of the metal. Twenty or more of these glasses, are placed in a sand-bath, and a moderate heat is applied, gradually increasing, till by the time that the acid is saturated, it is nearly boiling. The nitrat of silver being now decanted off, a fresh quantity of stronger acid is added and is boiled on the metal till it is nearly saturated: by this time almost the whole of the silver is taken up, and the undissolved residue appears like a heavy brown mud, consisting of the gold divided into very fine particles, and a little silver. The nearly saturated acid is now poured off, and replaced by a third portion of still stronger pure nitrous acid: this is made to boil, and is continued at the same temperature, till the production of nitrous gas ceases, and the bubbles become large, which is a sign that the whole of the silver is dissolved. The acid being poured out and reserved for the first part of a future similar process, the gold is washed with repeated portions of hot water, till the washings give no stain to a piece of polished copper on being dropped on its surface. The edulcorated gold-powder being dried, is mixed with a little nitre and borax and melted; and is then perfectly pure. The unsaturated nitrat of silver, is reserved for the next parting: that which is saturated is poured boiling hot into a large wooden bowl lined with copper, and in which are laid several copper-plates: upon these the silver is precipitated in the metallic state in consequence of the superior affinity of the acid for copper: the plates are, from time to time, cleared of their silver crust, in order to expose a fresh surface to the acid, and expedite the entire decomposition of the nitrat of silver: this being effected, the nitrat of copper is poured off, the plates are scraped, and the silver after edulcoration, is melted with a little nitre, and is thus obtained pure. If the nitrat of silver be perfectly neutralized, its decomposition by copper, goes on slowly and imperfectly: this inconvenience, is, however, at once removed by the addition of a very few drops of nitrous acid. In proportion as the quantity of copper in the acid increases, and that of the silver diminishes, the remaining nitrat of silver requires more time and a greater heat to be decomposed, and even after long continued boiling with copper, a solution of any of the neutral muriats will throw down a white precipitate of muriated silver: it would appear, therefore, to be a saving both of time and expence, when the action of the copper begins to be languid, to throw down the remainder of the silver by an addition of common salt. The nitrat of copper obtained in the process of parting, is turned to good account by being employed in the preparation of *Verditer*, (see COLOUR-MAKING) and from the nitrat of lime resulting from this last, the acid is again procured by distillation in the usual manner, with green vitriol or sulphuric acid.

Separation of Gold from Platina—Platina being like gold, one of the perfect metals, that is, unoxydable by simple exposure to heat and air, cannot be got rid of by cupellation; nor can any of the various methods in which sulphur or a sulphuretted metal is employed as the precipitant, be made use of with success; for platina seems to have at least as little affinity for sulphur as gold itself has.

Mercury, although capable of combining both with gold and platina, unites with the former much more readily than with the latter: upon this fact is founded a method of separating these metals, which, though imperfect, may be advantageously applied as a preparatory process. When the gold contains so large a proportion of platina as to be brittle, it must be pulverized in a mortar; but if the alloy is ductile, it must be reduced to small pieces by granulation. This being done, some mercury, seven or eight times the weight of the alloy, is to be heated to ebullition in an iron crucible, and the alloy, previously made red hot, is to be dropped into it, and the whole kept in digestion nearly at the boiling point for half an hour. The mixture being then emptied into an iron mortar and covered with hot water, is to be carefully triturated for some hours, renewing the water from time to time: by this means the gold will combine with the mercury, and a considerable proportion of the platina will rise to the surface of the amalgam in the form of a black powder, which may readily be separated. When, by this means, the alloy is purified as much as possible, the superfluous mercury is separated by straining

through a leather in the usual way, and the stiff amalgam is freed from the residual mercury by distillation.

The gold still holding a little platina, is now melted with thrice its weight of silver, and the mixture being granulated, is parted, with aquafortis, in the manner already described. Now, it is a singular circumstance, that although platina by itself, or even mixed with gold, is perfectly insoluble in nitrous acid; yet, when combined with a large proportion of silver, it is perfectly soluble in this menstrum, giving it a dark-yellowish brown tinge. When, therefore, this triple alloy is digested in nitrous acid, the silver and platina dissolve, leaving the gold behind. Of the gold thus separated and carefully washed, a few grains must be again melted with thrice their weight of silver, and treated with nitrous acid, in order to ascertain whether the platina is entirely got rid of; for, if it contains ½ per cent. or even less, the acid instead of being colourless, will be very sensibly tinged, in which case the process must be again repeated on the whole: this, however, is scarcely ever necessary where the previous trituration with mercury has been carefully performed. The silver contained in the nitrous solution, together with the platina, cannot be separated by copper, as is usual in common parting, because some of the platina would be precipitated at the same time; but, if a solution of common salt is had recourse to, the silver will be thrown down in the state of muriat, and the platina will remain in solution.

Another and more compendious method of separating gold from platina, is to dissolve the alloy in nitro-muriatic acid, and to throw down the gold by the addition of carbonat of soda, or a *large* quantity of green sulphat of iron, neither of which will at all decompose the solution of platina: the gold, when precipitated, is to be dried, mixed with a little nitre and borax, and fused, after which it will be in a state of absolute purity.

Purification of Gold by Cementation.— A very few words are necessary on this subject, as the process is now we believe wholly obsolete. It has been already mentioned, that nitrous acid is incapable of acting upon a small quantity of silver or copper, or other metals, by which gold may happen to be alloyed, where the proportion of this latter is so great as to cover and envelope the particles of alloy. This takes place, however, only when the acid is liquid, and applied at a temperature not exceeding that of ebullition: at a greater heat a much larger proportion of gold is required to prevent the action of the acid on the base metal, so that by perseverance and judicious management, the gold may be obtained nearly pure. The process by which this is effected is called cementation, and is thus performed.

Take the impure gold and beat or laminate it till it is somewhat thinner than a guinea; then heat it red hot, and allow it to cool slowly, that it may be as soft as possible; select a sound cementing pot, which is an earthen vessel shaped like a low hollow cylinder closed at one end, and cover its bottom to the heighth of about a finger's breadth, with a cement composed of one part of nitre, two parts of calcined sulphat of iron, and two parts of powdered tiles ground together to a fine powder, and moistened with urine; upon this cement place a single layer of gold plate, then another layer of cement, and so on alternately till the pot is full, observing that the upper as well as the under layer is of cement; then lute on very accurately a cover, and place the pot in a furnace, so that it may be kept at a moderate red heat for twenty-four hours, care being taken not to increase the temperature so as to endanger the fusion of the gold. At this heat the metal being softened, and the acid being liberated in a very active state, the gold is penetrated more or less by it, and the silver and other metals, except platina, that the gold may contain, are corroded and oxydated. When the pot is removed from the fire, it must be carefully unpacked, and the gold plates boiled first in water, and then in dilute nitrous acid, by which they will be separated from the metallic salt and oxyd, and will be found when assayed, to be considerably purer than at first. Every repetition of the process renders the gold purer, but in a decreasing ratio; so that it is not worth while to persevere in it longer than four or five times.

If common salt is substituted to nitre in the cement mentioned above, muriatic acid gas will be liberated instead of nitrous acid, and will be found to be equally efficacious, acting only on the alloy of the gold; but care must be taken not to employ both nitre and muriat of soda in the same cement, otherwise nitro-muriatic acid will be produced, and the gold as well as the alloy will be corroded.

The only purpose to which cementation is now applied, is to give a superficial, and therefore, in some measure, fraudulent fineness to gold highly alloyed.

In foreign countries, where trinkets and small work, are required to be submitted to the assay of the touch, a variety of needles are necessary; but they are not

much used. They afford, however, a degree of information, which is more considerable than might at first be expected. The attentive assayer not only compares the colour of the stroke made upon the touch-stone by the metal under examination, with that produced by his needle, but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes, perfectly alike in colour, are made upon the stone, he may then wet them with aqua fortis, which will affect them very differently, if they be not similar compositions; or, the stone itself may be made red-hot by the fire, or by the blow-pipe, if thin black pottery be used, in which case, the phenomena of oxidation will differ according to the nature and quantity of the alloy.

Gold ores may be *assayed in the moist way* by pounding them very fine, weighing a determinate portion, and attempting their solution in nitric acid, which will dissolve the matrix if it consist of calcareous earth; or if it be sulphat of lime, the powder may be digested in aqua regia, as long as any metallic substance is taken up; after which the gold may be precipitated by an addition of sulphat of iron, which will cause it to fall down in the middle state. See ASSAYING.

Physical properties of Gold, and preparation of Gold-leaf and Gilt-wire.—The colour of pure gold by reflected light, is a full bright yellow, verging on one hand towards orange, and on the other towards brass-yellow: it is remarkable, that gold fused with borax, becomes considerably paler than usual; and on the other hand, when fused with nitre, it becomes more highly coloured, without any other perceptible change being induced by either of these salts: hence, as this metal is reckoned beautiful in proportion to the fullness and brilliancy of its colour, the borax flux used by the goldsmiths is generally mixed with a sufficient quantity of nitre to counterbalance its discolouring property. The colour of gold when in high fusion, is blueish-green, of nearly the same tint with that of gold, by transmitted light: this latter may conveniently be observed by laying a leaf of gold between two thin plates of colourless glass, and holding it between the eye and a strong light.

The specific gravity of gold is only inferior to that of platina: with regard to its precise amount a considerable variation may be observed on comparing the reports of different authors, one stating it as high as 20. and another as low as 18.75. This difference is no doubt, in part, attributable to slight impurities in the gold itself, partly also to imperfection in the balances made use of, to differences of temperature, to the gold's being cast in sand or metal, to its being hammered or not, and to other causes, which, in the article ALLOY we have briefly pointed out, as affecting the specific gravity of metallic substances. According to an experiment by Mr. Ellicot, whose accuracy is well known, the specific gravity of an ingot of gold refined by antimony, was equal to 19.184, and of the same when hammered, to 19.207. According to Lewis, the specific gravity of fine gold at 58° Fah. amounted to 19.376. Brisson reports the specific gravity of fine gold in ingot to be equal to 19.258, and of the same when hammered, to 19,361.

In hardness this metal ranks somewhat above silver and below copper. It is extremely flexible, and so tough, that when at length by repeated bendings it is made to break, both the fractured pieces appear terminated by a wedge-shaped extremity. From its softness and toughness, it receives with perfect exactness the impression of the dies in coining, and for the same reasons it does not file freely, clogging up the teeth of the instrument in a very short time. It possesses little elasticity or sonorousness. It receives great brilliance from the burnisher, but not from the action of polishing powders. It is inodorous and insipid. The tenacity of gold is by no means so great as was supposed by the earlier chemists; it is inferior in this respect to iron, copper, platina, and silver. A wire of gold one-tenth of an inch in diameter, will support about 254lbs. avoirdupois, before it breaks. It is extremely malleable both when hot and cold, and very ductile.

In consequence of the high commercial value of gold, it is scarcely ever employed in mass, or in thick plates for ornamental purposes, but advantage has been taken of its remarkable malleability, to reduce it into leaves of an almost incredible thinness, so that, in this state, notwithstanding its high specific gravity, it will float in the air like a feather. Of the ingenious art called *Gold beating*, we shall proceed to give a short account.

The gold selected for this purpose is as pure as possible; the quantity used at one time by the English artists is two ounces. This being melted in a black lead crucible with some borax, is poured into an iron mould previously heated and greased, by which it is formed into a plate six or eight inches long, and three-quarters of an inch wide. This plate is

heated red hot, in order to burn off the tallow, and is then extended by forging on an anvil, and afterwards passed between steel rollers, till it becomes a long ribband as thin as paper. The ribband is now cut into 150 equal pieces, each of which is forged on an anvil, till it is about an inch square, after which they are well annealed Each of the squares in this state weighs six grains and four tenths, and in thickness is equal to $\frac{1}{766}$ of an inch. The 150 plates of gold thus produced, are interlaid with pieces of very fine vellum about four inches square, and about twenty vellum leaves are placed on the outsides; the whole is then put into a case of parchment, over which is drawn another similar case, so that the packet is kept close and tight on all sides. Being now laid on a smooth block of marble, from 200 to 600 lbs. in weight, the heavier the better, the workman begins the beating with a round-faced somewhat convex hammer, called the *cutch* hammer, weighing sixteen pounds; the packet is turned occasionally upside down, and beaten with strong but not acute strokes, till the gold is extended nearly to an equality with the vellum leaves, to ascertain which the packet is opened from time to time, and also bent and rolled between the hands to facilitate the extension of the gold between the leaves. The first part of the process being completed, the packet is then taken to pieces and each leaf of gold is divided into four with a steel knife; the 600 pieces thus produced are interlaid with pieces of ox-gut, of the same dimensions and in the same manner as the vellum. The beating is continued, but with a lighter hammer called the *shoddering* hammer, and weighing about twelve pounds, till the gold is brought to the same dimensions as the interposed membrane. It is now again divided into four, by means of a piece of cane cut to an edge, the leaves being by this time so light that any accidental moisture condensing on an iron blade, would cause them to adhere to it. The 2400 leaves hence resulting are parted into three packets, with interposed membrane as before, and beaten with the *finishing* or *gold* hammer, weighing about ten pounds, till they acquire an extent equal to the former. The packets are now taken to pieces, and the gold leaves, by means of a cane instrument and the breath, are laid on a flat leathern cushion and cut one by one to an even square, by a cane frame; they are lastly laid in books of 25 leaves each, the paper of which is previously smoothed and rubbed with red bole, to prevent them from adhering. Hence it appears that each of the inch-square pieces, into which the ribband of gold was divided, is extended by beating to 196 square inches, or 16 leaves, weighing 0.4 of a grain each, and not exceeding in thickness $\frac{1}{150136}$ of an inch. Every grain of gold furnishes 30.6 square inches.

Gold wire, as it is called, is in fact only silver wire gilt, and is prepared in the following manner. A solid cylinder of fine silver weighing about twenty pounds, is covered with thick leaves of gold which are made to adhere inseparably to it by means of the burnisher: successive laminæ are thus applied, till the quantity of gold, if intended for common gold wire, amounts to 100 grains for every pound troy of silver; if for double gilt wire, to about 140 grains. This gilt silver rod is then drawn successively through holes made in a strong steel plate till it is reduced to the size of a thick quill, care being taken to anneal it accurately after each operation. The succeeding process is similar to the former, except that a mixed metal somewhat softer than steel is employed for the drawing plates, in order to prevent the gilding from being stripped off, and no further annealing is requisite after it is brought to be as slender as a crow-quill. When the wire is spun as thin as is necessary, it is wound on a hollow copper bobbin, and carefully annealed by a very gentle heat: finally it is passed through a flatting mill, and the process is complete.

According to Dr. Halley, six feet in length of the finest gilt wire before flatting, will counterpoise no more than a grain: and as the gold is not quite $\frac{1}{57}$ of the whole, a single grain of gold thus extended will be 345.6 feet long. By the operation of flatting, the length of the wire is increased about a seventh, and its width is equal to $\frac{1}{96}$ of an inch: hence the surface occupied by one grain is equal to 98.7 square inches, with a thickness of $\frac{1}{490444}$ of an inch.

Gold requires for its fusion a low white heat equivalent to 32° of Wedgewood, or 1300 of Fahrenheit, and in this state its surface appears of a luminous blueish green colour. Gold may be alloyed with various metals. When gold is rendered standard by copper, that is, when the proportion of this last amounts to 38 grains in the ounce, the resulting alloy is of a deep yellow colour inclining to red; is harder than pure gold, but perfectly ductile. Its specific gravity is less than that of the mean of its ingre-

dients in a remarkable degree. Equal parts of copper and gold also form a perfectly ductile alloy. It is not however every kind of reputedly pure copper which can safely be used for alloying gold: even the Swedish dollar copper occasionally renders the gold with which it is mixed, as brittle as glass: this appears to be owing to the lead and antimony which most copper contains, and which though not in sufficient quantity to affect in any material degree the ductility of the copper itself, are fully adequate to destroy the ductility of the gold with which they are mixed; since no more than $\frac{1}{1920}$ of either of these metals is enough for this purpose, as we have already mentioned.

In the year 1792, a law was passed for establishing a mint, and for regulating the coins of the United States: by this law the following gold coins were to be struck.

1. Eagles; each to be of the value of ten dollars, and to contain two hundred and forty-seven and one-eighth grains of pure gold, or two hundred and seventy grains of standard gold.

2. Half eagles; each to be of the value of five dollars, and to contain 123 grains of pure gold, or 135 grains of standard gold.

3. Quarter eagles; each to be of the value of two dollars and fifty cents, and to contain sixty-one seven-eights of pure gold, or sixty-seven four-eights grains of standard gold.

Gold Coin, *Gold Wire*, *Gold Leaf*, } See Gold.

Gold Thread, or *spun gold*, is flatted gold warped or laid over a thread of silk, by twisting it with a wheel and iron bobbins. To dispose the wire to be spun or silk, they pass it between two rollers of a little mill: these rollers are of nicely polished steel, and about three inches in diameter. They are set very close to each other, and turned by means of a handle fastened to one of them which gives motion to the other. The gold wire in passing between the line is rendered quite flat, but without losing any of its gilding; and is rendered so exceedingly thin and flexible, that it is easily spun on silk thread by means of a hand wheel, and so wound on a spool or bobbin.

Gold Brocade, is a stuff of gold, raised and enriched with flowers, foliages, and other ornaments, according to the fancy of the merchant or manufacturer. Formerly the word signified a stuff wove all of gold, both in the warp and in the woof. In manufacturing brocades, the flatted gilt wire is spun on threads of yellow silk, approaching to the colour of gold. The machinery used, where a number of threads are twisted at once by the turning of a wheel, is rather complicated. For further information consult Lewis' Commerce of Arts, where this manufacture, as well as the mode of cleansing brocades, may be found at length.

Gold Plates, for enamelling. See Enamelling.

Gold (shell,) see Gilding.

Gold Size, for burnished gilding, as well as for japanners. See Gilding and Japanning.

Gold, recovering of from gilt work. This may be effected in several ways. If silver be gilt, the gold may be removed by nitro-muriatic acid, which dissolves it. See Gold.

Gold Lacquer. See Lacquer.

GRANULATION. The process by which a metal is reduced into grains is called granulation. This is for the most part effected by melting the metal, and then pouring it in a very slender stream into cold water. As soon as the metal touches the water it divides into drops, which have a tendency to a spherical shape, and are more or less perfect according to the thinness of the stream, the height from which it falls, and the temperature both of the water and of the metal. Tin, and some others of the most fusible metals, may be reduced to much finer grains than can be effected in the usual way, by pouring it when melted into a wooden box smeared on the inside with chalk, and shaking it violently before it has time to become solid. By this means tin is reduced to a fine powder; and there is no doubt but that the less fusible metals might likewise be so pulverized by a similar manipulation.

GRAPHITE, or Plumbago. See Coal.

GRAVITY, SPECIFIC. See Specific Gravity.

GREEN, in Dyeing. See Dyeing.

GREEN EARTH. This is a mineral, found in different places; and, when of a good colour, is made use of as a pigment by painters. See Colour Making.

GREEN VITRIOL, *Sulphat of Iron*, or *Copperas*. See Iron and Copperas.

GUM ELASTIC. See Caoutchouc.

GUM. The mucilage of vegetables. It is usually transparent, more or less brittle when dry, though difficultly pulverable; of an insipid, or slightly saccharine taste; soluble in, or capable of combining with water in all proportions, to which it gives a gluey adhesive consistence in proportion as its quantity is great-

er. It is separable, or coagulates by the action of weak acids; insoluble in alcohol, or in oil; and capable of the acid fermentation, when diluted with water. The destructive action of fire causes it to emit much carbonic acid, and converts it into coal without exhibiting any flame. Distillation affords water, acid, a small quantity of oil, a small quantity of ammonia, and much coal.

These are the leading properties of gums, rightly so called; but the inaccurate custom of former times applied the term gum to all concrete vegetable juices; so that in common we hear of gum copal, gum sandarach, and other gums, which are either pure resins, or mixtures of resins with the vegetable mucilage.

The principal gums are, 1. The common gums, obtained from the plum, the peach, the cherry tree, &c.—2. Gum Arabic, which flows naturally from the acacia in Egypt, Arabia, and elsewhere. This forms a clear transparent mucilage with water.—3. Gum Seneca, or Senegal. It does not greatly differ from gum Arabic: the pieces are larger and clearer; and it seems to communicate a higher degree of the adhesive quality to water. It is much used by calico-printers and others. The first sort of gums are frequently sold by this name, but may be known by their darker colour.—4. Gum Adragant or Tragacanth. It is obtained from a small plant of the same name growing in Syria, and other eastern parts. It comes to us in small white contorted pieces resembling worms. It is usually dearer than other gums, and forms a thicker jelly with water.

Mr. Willis has found, that the root of the common blue bell, hyacinthus non descriptus, dried and powdered, affords a mucilage possessing all the qualities of that from gum arabic. The roots of the vernal squill, white lily, and orchis, equally yield mucilage.

GUM-RESIN. These are for the most part the juices of various trees of tropical climates, which ooze out from natural cracks in the bark, or artificial incisions, and harden by the sun and air into irregular roundish masses. The gum-resins therefore are the juices of the respective plants as nearly as possible in their natural state, and they retain the sensible properties of smell and taste for a very great length of time. A similar juice, but inferior in quality, may also be obtained from some of them by macerating in water the entire vegetable, or part of the vegetable that yields it, and evaporating the water to an extract, but this is very seldom practised.

The gum-resins are almost exclusively employed in medicine, and only a very few of them have engaged the attention of chemists. Though they agree in those leading characters which constitute a *gum-resin*, there is a vast difference in the composition of the several species when examined chemically, and they pass almost by imperceptible gradations either into the pure resins, or into the extracts and gummy mucilages.

Of the most important gum-resins may be enumerated, myrrh, galbanum, guaiacum, asafœtida, ammoniacum, olibanum, sagapenum, and perhaps opium. The chemical analysis of these and others where it presents any important results, will be given under the respective articles.

The general or characteristic properties of a *gum-resin* are (as its name imports) such as would be produced by a natural mixture of gum and resin. To the resinous part they chiefly owe the property of burning with much flame, melting in drops by the heat; of giving by distillation a large portion of volatile oil and some ammonia. To the gummy part they owe their partial solubility in water, so that when rubbed with this fluid they form an emulsion, generally whitish, which remains a considerable time turbid, and even when by rest the gum resin has again subsided, the clear liquor always retains some of the taste and smell of the substance employed.

Some of the gum-resinous juices are also mixed with a kind of EXTRACT, or a coloured and bitter substance soluble in water and alcohol, and also TAN is very commonly united to them. On the whole the term Gum-Resin is more properly a pharmaceutical than a chemical distinction.

GUNPOWDER, is a mechanical mixture of nitre, charcoal, and sulphur, the explosive powers of which are familiar to every one. The method of manufacture is extremely simple, but considerable precautions are necessary in the selection of pure and good materials, in ensuring a very intimate admixture, and in avoiding any strong collision or any other event which might produce fire, and thus kindle the powder, and be productive of the most dreadful accidents.

Among the number of improvements which have been made, in the machinery and apparatus, for the manufacture of gunpowder, in the United States, as well as to the improvements in refining saltpetre, and in the preparation of coal, to which the excellence of some American gunpowder is attributed, we may add, that our country is indebted to the Messrs.

Duponts, of Brandywine, as well as to Mr. John H. Worrell, of the Frankford (formerly Decatur's) mills, Mr. Whelen, of Hall mills, and others, for the production of this article, which is now equal, if not superior, to the French and English powder.

The actual mode of making gunpowder cannot be better described than from the account given by Mr. Coleman, of the Royal Powder Mills of Waltham Abbey. The ingredients of gunpowder are taken in the following proportion, namely, 75 of saltpetre, 15 of charcoal, and 10 of sulphur. The saltpetre used is almost entirely that which is imported from the Indies, which comes over in the rough state mixed with earthy and other salts, and is refined by solution, evaporation, and crystallization. After this it is fused in a moderate heat, so as to expel all the pure water, but none of the acid, and is then fit for use. The great use of refining the nitre is to get rid of the deliquescent salts, which by rendering the powder made of it liable to become damp by keeping, would most materially impair its goodness. The sulphur used is imported from Italy and Sicily, where it is collected in its native state in abundance. It is refined by melting and skimming, and when very impure, by sublimation. It should seem that the English sulphur, extracted in abundance from some of the copper and other mines, is too impure to be economically used for gunpowder, requiring expensive processes of refining.

The charcoal formerly used in this manufacture was prepared in the usual way of charring wood, piles being formed of it and covered with sods or fern, and suffered to burn with a slow smothering flame. This method however cannot with any certainty be depended on to produce charcoal of an uniformly good quality, and therefore a most essential improvement has been adopted in this country, to which the present superior excellence of American powder may be in a good measure attributed, which is, that of enclosing the wood, cut into billets about nine inches long, in iron cylinders placed horizontally, and burning them gradually to a red heat, continuing the fire till every thing volatile is driven off, and the wood is completely charred. But as the pyroligneous acid, the volatile product of the wood heated *per se*, is of use in manufacture, it is collected by pipes passing out of the iron cylinder, and dipping into casks where the acid liquor condenses. This acid is used in some parts of calico-printing, chiefly as the basis of some of the iron liquors and mordants for dark-coloured patterns. The wood before charring is barked. It is generally either alder or willow, or dog-wood, but there does not appear to be any certain ground for preferring one wood to another provided it be fully charred.

The above three ingredients being prepared, they are first separately ground to fine powder, then mixed in the proper proportions, after which the mixture is fit for the important operation of thoroughly incorporating the component parts in the mill. A powder mill is a slight wooden building, with a boarded roof, so that in the event of any moderate explosion, the roof will fly off without difficulty, and the sudden expansion will thus be made in the least mischievous direction. Stamping mills were formerly used here, which consisted simply of a large wooden mortar, in which a very ponderous wooden pestle was made to work, by the power of men, or horses, or water, as convenience directed. These performed the business with very great accuracy, but the danger from over-heating was found to be so great, and the accidents attributable to this cause were so numerous, that stamping mills have been mostly disused in large manufactures, and the business is now generally performed by two stones placed vertically, and running on a bed-stone or trough.

The mixed ingredients are put on this bed-stone in quantities not exceeding 40 or 50 pounds at a time, and moistened with just so much water, as will bring the mass in the grinding to a consistence considerably stiffer than paste, in which it is found by experience that the incorporation of the ingredients goes on with the most ease and accuracy. These mills are worked either by water or horses.

The composition is usually worked for about seven or eight hours before the mixture is thought to be sufficiently intimate, and even this time is often found, by the inferior quality of the powder, to be too little. The fine powder manufactured at Battle in Sussex, is still however made in large mortars or stamping mills, in the old way, with heavy lignum vitæ pestles. Only a very few pounds of the materials are worked at a time.

The composition is then taken from the mills and sent to the *corning-house*, to be corned or grained. This process is not essential to the manufacture of perfect gunpowder, but is adopted on account of the much greater convenience of using it in grains than in fine dust. Here the stiff paste is first pressed into hard lumps, which are put into circular sieves with

parchment bottoms, perforated with holes of different sizes, and fixed in a frame connected with a horizontal wheel. Each of these sieves is also furnished with a *runner* or oblate spheroid of lignum vitæ, which being set in motion by the action of the wheel, squeezes the paste through the holes of the parchment bottom, forming grains of different sizes. The grains are then sorted and separated from the dust by sieves of progressive dimensions.

They are then *glazed* or hardened, and the rough edges taken off, by being put into casks, filling them somewhat more than half-full, which are fixed to the axis of a water-wheel, and in thus rapidly revolving the grains are shaken against each other and rounded, at the same time receiving a slight gloss or glazing. Much dust is also separated by this process The glazing is found to lessen the force of the powder from a fifth to a fourth, but the powder keeps much better when glazed, and is less liable to grow damp.

The powder being thus corned, dusted and glazed, is sent to the stove-house and dried, a part of the process which requires the greatest precautions to avoid explosion, which in this state would be much more dangerous than before the intimate mixture of the ingredients.

The stove-house is a square apartment, three sides of which are furnished with shelves or cases, on proper supports, arranged round the room, and the fourth contains a large cast-iron vessel called a *gloom*, which projects into the room, and is strongly heated from the outside, so that it is impossible that any of the fuel should come in contact with the powder. For greater security against sparks by accidental friction, the glooms are covered with sheet copper, and are always cool when the powder is put in or taken out of the room. Here the grains are thoroughly dried, losing in the process all that remains of the water added to the mixture in the mill, to bring it to a working stiffness. This Mr. Coleman finds to be from three to five parts in 100 of the composition. The powder when dry is then compleat.

The government powder for ordnance of all kinds as well as for small arms, is generally made at one time, and always of the same composition; the difference being only in the size of the grains as separated by the respective sieves.

A method of drying powder by means of steam-pipes running round and crossing the apartment has been tried with success: by it all possibility of an accident from over-heating is prevented. The temperature of the room when heated in the common way by a gloom-stove is always regulated by a thermometer hung in the door of the stoves.

The strength of the powder is sometimes injured by being dried too hastily and at too great a heat, for in this case some of the sulphur sublimes out (which it will do copiously at a less heat than will inflame the powder) and the intimate mixture of the ingredients is again destroyed. Besides if dried too hastily, the surface of the grain hardens leaving the inner part still damp.

Mr. Coleman deduces from experiment the following inferences, namely: that the ingredients of gunpowder only pulverized and mixed have but a very small explosive force: that gunpowder granulated after having been only a short time on the mill, has acquired only a very small portion of its strength, so that its perfection absolutely depends on very long-continued and accurate mixture and incorporation of the ingredients: that the strength of gunpowder does not depend on granulation, the dust that separates during this process being as strong as the clean grains: that powder undried, is weaker in every step of the manufacture than when dried: and lastly, that charcoal made in iron cylinders in the way already mentioned, makes much stronger powder than common charcoal. This last circumstance is of so much consequence, and is so fully confirmed by experience, that the charges of powder now used for cannon of all kinds have been reduced one-third in quantity, when this kind of powder is employed.

In barrelling powder, particular care must be taken to avoid moisture, and this business is also generally reserved for dry weather.

When powder is only a little damp, it may be restored to its former goodness merely by stoving, but if it has been thoroughly wetted, the nitre (the only one of the ingredients soluble in water) separates more or less from the sulphur and charcoal, and by again crystallizing, cakes together the powder in whitish masseswhich are a loose aggregate of grains covered on the surface with minute efflorescences of nitre. In this case the spoiled powder is put into warm water merely to extract the nitre, and the other two ingredients are separated by straining and thrown away.

The specific gravity of gunpowder is estimated by Count Rumford to be about 1.868.

The strength and goodness of powder is judged of in several ways, namely, by the colour and feel, by the flame when a

small pinch is fired, and by measuring the actual projectile force by the *eprouvette*, and by the distance to which a given weight will project a ball of given dimensions under circumstances in all cases exactly similar.

When powder rubbed between the fingers easily breaks down into an impalpable dust, it is a mark of containing too much charcoal, and the same if it readily soils white paper when gently drawn over it. The colour should not be absolutely black, but is preferred to be more of a dark blue with a little cast of red. The trial by firing is thus managed; lay two or three small heaps of about a dram each on clean writing paper, about three or four inches asunder, and fire one of them by a red-hot iron wire: if the flame ascends quickly with a good report, sending up a ring of white smoke, leaving the paper free from white specks and not burnt into holes, and if no sparks fly off from it, setting fire to the contiguous heaps, the powder is judged to be very good, but if otherwise, either the ingredients are badly mixed, or impure.

The common eprouvettes or powder-triers are small strong barrels, in which a determinate quantity of the powder is fired, and the force of expansion measured by the action excited on a strong spring or a great weight.

Another method often adopted, is to fire a very heavy ball from a short mortar with a given weight of the powder and to find the range of projection. The French eprouvette for government powder is a mortar of 7 inches (French) in calibre, which with three ounces of powder should throw a copper globe of 60lbs. weight to the distance of 300 feet. No powder is admitted which does not answer this trial.

Both these methods have been objected to, the former because the spring is moved by the instantaneous stroke of the flame and not by its continued pressure, which is somewhat different; and the other on account of the tediousness attending its use when a large number of barrels of powder are to be tried. Another method, which unites accuracy with dispatch, is to suspend a small cannon as a pendulum, to fire it with powder only, and to judge of the force of explosion by that of the recoil, which in this circumstance is a greater or less arc of a circle. That which Dr. Hutton employs on this principle is a small cannon about one inch in the bore, the charge of which is two ounces of powder.

The cause and measure of the expansive force of fired gunpowder has been much investigated. It is generally allowed to be chiefly owing to the sudden generation of a quantity of gas or elastic vapour, the chemical constitution of which will be presently mentioned

To determine the elasticity and quantity of this elastic vapour produced from a given quantity of powder, Mr. Robins premises, that its elasticity is equally increased by heat and diminished by cold as that of common air (which is confirmed by Mr. Dalton's late experiments) and consequently its weight is the same with he weight of an equal bulk of air of the same elasticity and temperature. Hence, and from direct experiments, he concludes that the elastic fluid produced by the firing of gunpowder is nearly three tenths of the weight of the powder itself, which, expanded to the rarity of common air, is about 244 times the bulk of the powder. Hence it would follow, that the mere conversion of confined powder into elastic vapour, would exert against the sides of the containing vessel an expansive force 244 times greater than the elasticity of common air, or in other words, than the pressure of the atmosphere. But to this is to be superadded all the increase of expansive power produced by the heat generated, which is certainly very intense, though its exact degree cannot be ascertained. Supposing it to be equal to the full heat of red-hot iron, this would increase the expansion of common air (and also of all gasses) about four times, which in the present instance would increase the 244 to nearly 1000, so that in a general way it may be assumed, that the expansive force of closely confined powder at the instant of firing is 1000 times greater than the pressure of common air: and as this latter is known to press with the weight of $14\frac{3}{4}$ pounds on every square inch, the force of explosion of gunpowder is 1000 times this, or, 14750lb. or about six tons and a half on every square inch. This enormous force, however, diminishes in proportion as the elastic fluid dilates, being only half the strength when it occupies a double space, one-third of the strength when in a triple space, and so on.

Mr. Robins found that the strength of powder is the same in all variations of the density of the atmosphere, but not so in every state of moisture, being much impaired by a damp air, or with powder damped by careless keeping or any other cause, so that the same powder which will discharge a bullet at the rate of 1700 feet in a second in dry air, will only pro-

pel it about 1200 feet when the air is fully moist, and a similar difference holds between dry and moist powder.

A very considerable variation is found in the proportions of the ingredients of the powder of different nations and different manufactories, nor is it exactly ascertained whether there is any one proportion which ought always to be adhered to and for every purpose. The powder made in England, is the same for cannon as for small arms, the difference being only in the size of the grains, but in France it appears that there were formerly six different sorts manufactured, namely, the strong and the weak cannon powder, the strong and the weak musquet powder, and the strong and the weak pistol powder. The following are the proportions in each, though the reason of this nicety of distinction is not very obvious. For the strong cannon powder the nitre, sulphur, and charcoal were in the proportions of 100 of the first, 25 of the second, and 25 of the third: for the weak cannon powder, 100, 20, and 24: for the strong musquet powder, 100, 18, and 20; for the weak, 100, 15, and 18: for the strong pistol powder, 100, 12, and 15; for the weak, 100, 10, and 18.

The Chinese powder appears by the analysis of Mr Napier to be nearly in the proportions of 100 of nitre, 18 of charcoal, and 11 of sulphur. This powder which was procured from Canton was large-grained, not very strong, but hard, well-coloured, and in very good preservation.

The sulphur is not (properly speaking) a necessary ingredient in gunpowder, since nitre and charcoal alone, well mixed, will explode, but the use of the sulphur seems to be to diffuse the fire instantaneously through the whole mass of powder. But if the following experiments are correct, it should seem that the advantage gained by using sulphur in increasing the force of explosion only applies to small charges, but in quantities of a few ounces, the explosive, or at least the *projecting* force of powder without sulphur, is full as great as with sulphur.

The following are a few out of many trials made at the Royal Manufactory at Essone, near Paris, in the year 1756, to determine the best proportions of all the ingredients. Of powder made with nitre and charcoal alone, 16 of nitre and 4 of charcoal was the strongest, and gave a power of 9 in the eprouvette. With all three ingredients, 16 of nitre, 4 of charcoal, and 1 of sulphur, raised the eprouvette to 15, and both a less and a greater quantity of sulphur produced a smaller effect. Then diminishing the charcoal, a powder of 16 of nitre, 3 of charcoal, and 1 of sulphur gave a power of 17 in the eprouvette, which was the highest produced by any mixture. This last was also tried in the mortar-eprouvette against the common proof powder, and was found to maintain a small superiority. The powder made without sulphur in the proportions above indicated was also tried in the mortar-eprouvette, and with the following singular result: when the charge was only two ounces it projected a sixty pound copper ball 213 feet, and the strongest powder with sulphur projected it 249 feet; but in a charge of three ounces, the former projected the ball 475 feet and the latter only 472 feet: and on the other hand the great inferiority of force in the smaller eprouvette of the powder without sulphur has been just noticed.

Gunpowder is reckoned to explode at about 600° Fahr but if heated to a degree just below that of faint redness, the sulphur will mostly burn off, leaving the nitre and charcoal unaltered. The gasses produced by the explosion of powder have not been analyzed with accuracy since the discovery of all the varieties of gasses with the basis of carbon, but they are certainly carbonic acid, sulphureous acid gas, and carburetted hydrogen. The residue is chiefly a sulphuret of potash, formed by a part of the sulphur uniting with some of the alkali of the nitre, and hence the hepatic smell of a foul and damp gun-barrel.

The analysis of gunpowder performed with sufficient accuracy for most practical purposes, is very easy and simple, but an absolutely accurate analysis is more difficult. The usual way is first to boil the powder with three or four times its weight of water, edulcorating it with more hot water till no saline taste remains. This extracts the nitre only, the quantity of which may be either ascertained by drying the residue and estimating as nitre all the loss of weight, or more directly by evaporating the watery solution. If the residue, consisting of the sulphur and charcoal, is now spread on an earthen plate of any kind and slowly heated, the sulphur takes fire and burns off gradually, whilst the charcoal remains untouched, when the heat is kept down sufficiently. Beaumé found however, that when all the sulphur is expelled which will be driven off in this heat, a certain portion will still remain and will not burn away at a lower temperature than will consume the charcoal: so that to the last the burning residue will smell strongly sulphureous. This retained portion of sulphur he finds, by the results of many

other experiments, to be very uniformly about one twenty-fourth part of the whole sulphur employed; whence for all common purposes an adequate correction may be made, by estimating that the slow weak combustion of the residue, after the nitre has been got out, destroys only $\frac{23}{24}$ of the sulphur instead of the whole. On trying to separate them by an alkaline solution, he found some of the sulphur to remain undissolved and still adhering to the charcoal. The way to ensure perfect accuracy in analysis, would be first to separate the nitre by hot water, then to acidify all the sulphur by the nitric acid, to dissolve and to precipitate it by a solution of nitrat or muriat of barytes, and from the known constituents of this salt to find the quantity of sulphur, whilst the charcoal here remains perfectly untouched.

The discovery of the astonishing fulminating property of the salts with the oxymuriatic acid, led several chemists to the idea of substituting the oxymuriat of potash to the nitre in the manufacture of gunpowder, and experiments have been made on a sufficient scale to shew that this gunpowder far exceeds the common powder in energy of explosive power. The oxymuriats however appear to act in a different manner from the mixtures with nitre, and to exert all their power extremely suddenly and in a very small space, so as to destroy every substance in immediate contact with them at the time of explosion, but to be inferior in projectile force to common gunpowder. All the explosive compounds with the oxymuriats have also the very dangerous property of exploding with very moderate friction, and hence they have never been employed in the large way.

GUN-FLINTS, manufacture of. See Flint.

GYPSUM. This is a native combination of lime and sulphuric acid. There are several varieties. It is used in agriculture as a manure, and also, in stucco work. It has been found in various parts of the United States, in considerable quantities. See Agriculture.

H.

HÆMATITE. See Iron.

HAHNEMAN'S WINE TEST.—The following description of a liquor for discovering, in wines, the presence of such metals as are injurious to health, is by Dr. Hahneman.

The property which liver of sulphur and hepatic air possess, of precipitating lead of a black colour, has long been known, and this property has been made use of in the preparation of a liquor called *Liquor probatorius Wurtemburgicus*, by which it was supposed the purity of wines might be ascertained.

But, in examining wines which are suspected to be adulterated, this liquor can by no means be trusted to, because it precipitates iron of the same colour as it does lead, which is so poisonous a metal. For this reason, many respectable wine merchants have been thought guilty of adulterating their wines, to the great injury of their character.

Consequently there was still wanting a test or re-agent that should point out, in wines, the presence of such metals only as are injurious to health. This property the following liquor possesses, as it precipitates lead and copper of a black colour, arsenic of an orange colour, &c. It does not, however, precipitate iron, which frequently, by various means, gets unobserved into wines, but which is in many cases salutary, to the human frame.

Preparation of the new probatory liquor.—Mix together equal parts of oyster shells and crude brimstone, both finely powdered: put the mixture into a crucible, and place the crucible in a wind furnace. When it is heated, let the fire be suddenly increased till the crucible becomes of a white heat, in which state it is to be continued for about a quarter of an hour. The mass, when cold, is to be reduced to powder, and kept in a bottle closely stopped.

In order to prepare the liquor, one hundred and twenty grains of the above powder, and one hundred and eighty grains of cream of tartar, are to be put into a very strong bottle, which is to be filled up with common water, that has been previously boiled for about an hour

and then suffered to cool. The bottle must be immediately corked, and afterwards shaken from time to time. When it has remained still, for a few hours, the clear liquor must be decanted into small phials, capable of holding one ounce, into each of which, twenty drops of spirit of sea-salt have been previously dropped. The mouths of the phials must then be well closed with stopples, composed of wax mixed with a small quantity of turpentine.

If one part of the above liquor be mixed with three parts of the wine meant to be examined, the slightest impregnation of lead, &c. will be immediately discovered, by a very perceptible black precipitate. But, if the wine contains iron, the liquor will have no effect upon that metal.

When the above precipitate has subsided to the bottom, we may find out whether the wine contains any iron, by decanting the clear liquor, and adding to it a little salt of tartar; if there is any iron in the wine the liquor will immediately turn black.

Wines which are pure and unadulterated, remain clear after the addition of this liquor. See TESTS.

HAIR. The chemical composition of hair appears, by the experiments of Mr. Hatchett, to resemble very closely that of nail and horn. Boiling water extracts from hair a very small proportion of gelatin, and the hair after drying is somewhat stiffer and more brittle than before. The chief constituent of hair appears to be organic, condensed albumen.

Hair may be dyed permanently in several ways. A black or dark colour, which is generally desired, is given by many metallic solutions, particularly that of silver much weakened; but these are liable to corrode its substance, if not carefully used. Pallas relates that the women of Astracan dye their hair, while growing, of a fine glossy black, in the following way: twenty-five galls are first boiled in oil, then dried and powdered: to this is added, 3 drachms of green vitriol, one drachm of cream of tartar, and one drachm of indigo, and the whole stirred up with a quart of water, to which is added a handful of the dyeing herb *henne*. The hair is anointed with this over night, care being taken not to blacken the skin, and is washed off in the morning. This application gives a shining black which lasts several months.

If two drachms of lunar caustic be dissolved in eight ounces of water, a solution will be formed, which, applied frequently to the hair, blackens it. We lately examined a white or rather reddish white powder, for a perfumer of this city, which is sold to blacken hair, and found it to be composed of litharge, quick-lime, and whiting. It is applied when melted by water. The perukemakers dye hair black, by boiling it in an iron pot with water and litharge.

From numerous experiments Mr. Vauquelin infers, that black hair is formed of nine different substances, namely:

1. An animal matter, which constitutes the greater part; 2. A white concrete oil in small quantity: 3. Another oil of a greyish green colour, more abundant than the former; 4. Iron, the state of which in the hair is uncertain; 5. A few particles of oxide of manganese; 6. Phosphat of lime; 7. Carbonat of lime, in very small quantity; 8. Silex, in a conspicuous quantity; 9. Lastly, a considerable quantity of sulphur.

The same experiments shew, that red hair differs from black only in containing a red oil instead of a blackish green oil; and that white hair differs from both these only in the oil being nearly colourless, and in containing phosphat of magnesia, which is not found in them.

From this knowledge of the nature of the constituent principles of hair, Mr. Vauquelin thinks we may account for the various colours that distinguish it. According to him, the black colour will be owing to a black, and as it were bituminous oil, and perhaps likewise to a combination of sulphur with iron. Carrotty and flaxen hair will be occasioned by the presence of a red or yellow oil, which, when deepest, and mixed with a small quantity of brown oil, produces the dark red hair. Lastly, white hair is owing to the absence of the black oil and sulphuretted iron. He believes, that in the carrotty and flaxen, as well as in the white, there is always an excess of sulphur; since, on the application of white metallic oxides to them, such as those of mercury, lead, bismuth, &c. they grow black very speedily. The manner in which this substance acts on metallic bodies leads him to suspect, that it is combined with hydrogen.

Fine perfumed powder, for the hair.—Take a pound of Florentine orris-root, in fine powder; two ounces of powdered gum-benjamin and storax; yellow saunders a pound and a half; cloves, two drachms; some powdered dried lemon-peel. Mix the above, well powdered, and sift them through a lawn sieve, with twenty pounds of common starch, or common hair-powder.

HAIR POWDER.—This is generally

prepared from wheat, being the fecula or starch of grain. It is however, usually prepared from starch, by pulverization, &c. It is frequently adulterated with lime, and sometimes as Dr. Darwin says, with alum. See STARCH.

HAIR-ROPE-PUMP. See ENGINES.

HALTER-CAST. See FARRIERY.

HAM, the lower part of an animal's thigh, adjoining to the knee. It usually denotes the thigh of a hog. Hams may be cured by covering them with salt, which is to remain for 24 hours, then wipe them dry, and let them be placed in the following pickle for three weeks, viz. take one pound of brown sugar, a quarter of a pound of saltpetre, three and a half pints of salt, which is to be mixed with a sufficient quantity of water. See BACON. If hams, by keeping, should become tainted, they may be restored, as we have found by trying the experiment; by boiling them in water, in which an ounce of salt petre has been dissolved, and a few lumps of charcoal thrown in.

The following method of preserving hams, or other smoked meat through the summer, is extracted from the Archives of Useful Knowledge, conducted by Dr. James Mease.

Wrap up the meat in tow, of either flax or hemp, after shaking out the loose shives, and pack it in a tierce or barrel, taking care that there be next the tierce and between every piece of meat, a thick layer of tow packed in as close as possible: then set it away in a dry cellar or upper room. It is enough that the barrel or tierce be sufficient to keep the mice out, as no fly or insect will enter the tow.

Tow and flax are such bad conductors of heat, that a piece of ice will be preserved a long time wrapped up in tow. Cut straw also answers extremely well to keep hams in. Ashes are apt to communicate a bad taste to meat. Care should be taken to prevent the flies from having access to the meat before being packed away.

Various modes of preserving hams have been recommended; but the foregoing receipt has received the sanction of experience. A dry and completely dark room, will preserve hams in the best order.

HAT-MAKING. Hats are manufactured of wool, fur, &c. The making of hats being too well known to require minute description, we shall only observe, that it consists in furring the felt, according to the art of the hatter, and shapening the hat, which is then dyed in a liquid prepared of logwood, and a mixture of green and blue vitriol; when it is stiffened with common glue.

A patent was granted to a Mr. Golding, for a method of dyeing, staining, and colouring beaver hats green, or any other colour. The articles employed in dyeing are fustic, turmeric, saffron, alum, tartar, indigo and vitriol, with urine, or pearl ash, at the option of the dyer; which are used together, or separately, according to the colour required. Patents have also been granted for substitutes, or new materials, in this branch of manufacture, as, for *mole fur*, *kid hair*, water proof hats, in imitation of beaver, &c. which is extended to silk, linen, leather, cotton, or other material of wearing apparel. For further information on this subject, see *Repertory of Arts*, vol. 16. *Nicholson's Philosophical Journal*, vol. 1, 2, and 3, 4to. The dyeing of hats was noticed under the article DYEING, which see. Several patents have been obtained from the government of the United States for improvements in this art.

HEAT. The sensations expressed in common language by the words heat and cold, are of too simple a nature to require or to admit of definition. These *words*, however, are not always used in their true sense, but are indiscriminately applied both to the sensation itself, and to that which causes it. Thus, we say, that we are hot or cold; and that the fire or ice, which heats or cools us, is likewise hot or cold, though the sensations we experience are certainly very different things from that which enables bodies to excite them. It may also be remarked, that, in this ambiguous manner of speaking, there is another cause of uncertainty, which arises from the use of a variable standard of comparison. Every one knows, that the estimation of heat or cold differs in various persons, because each forms his judgment from his own sensations; and the same body may appear hot to one person, and cold to another, or hot and cold to the same person at different times; though the variation is not in the body itself, but in the state of the person in whom these sensations are excited. Hence, it appears necessary, in order to avoid error in the pursuit of inquiries concerning heat, that the sense of the words made use of should be accurately defined, and that some fixed standard of comparison be made use of instead of the human body; which, though fixed enough for the common affairs of life, is certainly not enough so for the purposes of science.

The word heat, in a philosophical sense, is used to denote the cause of the power which bodies possess of exciting the sensations of heat or coldness.

The word temperature denotes the state of the body, with respect to that

power. So that a body which excites a more intense sensation of heat or coldness, than another body, is said to possess a higher or lower temperature.

It has not yet been determined in what heat itself, or the cause of temperature, consists. Two opinions have long divided the scientific world One is, that heat consists of a peculiar motion or vibration of the parts of bodies, so that the temperature is higher, the stronger the vibration. The other is, that heat is a substance or fluid, the greater or less quantity of which produces a higher or lower temperature. The decision of this great question is highly deserving of the attention of philosophers. But it will not be necessary to consider its merits in our first steps of investigation, because the doubts respecting it will not impede our reasoning concerning such phœnomena as are well known. For, since effects are proportioned to their causes, we may speak of the quantities of heat in bodies, without deciding whether they be quantities of motion or quantities of matter; the relation of these quantities to each other, and not their peculiar nature, being the chief object of our research.

That heat is actually matter, which was an opinion held by some in very ancient times, is now pretty generally maintained; and it is as generally distinguished by the name *Caloric*. To that article, therefore, we refer, for what is at present known on the subject: the facts being the same, whether we understand by it a peculiar substance, or a power of producing certain effects.

Heat communicated to Rooms by steam, according to Mr. Neil Snodgrass, of Renfrew.—*Trans Soc. Arts*, *Vol.* 24.

Mr. Snodgrass was induced to try the effect of steam for warming the air of apartments (from observing the method of drying muslins by wrapping them round hollow cylinders heated by steam, which was practised near Glasgow) both on account of the saving of fuel it would produce, and its removing all danger of conflagration, to which mills, heated in the usual manner, are most exposed.

He put this method in practice at a mill at Dornach, with such success as to heat it completely with one *half* the fuel, that would be necessary for this purpose with the best constructed stoves; but as the apparatus for this mill was not as perfect as that afterwards contrived, it need not be here detailed.

Two cotton mills belonging to G. Houston, Esq. of Johnstone, were also warmed by steam; in one of these, six stories high, a lying pipe of cast iron, 5 inches in diameter, is carried along the middle of the cieling of the lower story, about two feet from the cieling, with a small declivity to carry off the water. This pipe heats the lower story, and from it arise tin pipes of 7½ inches in diameter, at intervals of 7 feet from each other, which, passing perpendicularly upwards through all the floors in the mill, form a line of heated columns in the middle of each room. In the other mill this plan has received some alterations on account of the irregularity of the building. Valves opening inwards were added to the tin pipes, to prevent their compression by accidental condensation of the stream; and another valve was placed opening outwards at the lower part of the apparatus, to permit the air contained in the pipes to pass as its place was occupied by steam.

Certificates of five other mills being heated in the same manner, to great advantage, by Mr. Snodgrass, were received by the Society for Arts, &c.

In new manufactories, where the mode of heating may be made an original part of the plan, Mr Snodgrass recommends an apparatus, of which the following is a description:

Vertical pipes of cast iron, about 7 inches in diameter in the lower stories, and 6 inches diameter in the upper stories, ascend from the bottom to the top of the mill, in the middle of the apartments, at about 7 or 8 feet distance from each other. These pipes come close to the beams in each story, and are contrived so as to support them by projecting pieces, like brackets, cast to them in the proper places, which go under the beams; and by wedges driven between them and the beams, each can be made to have a due bearing; and thus these pipes perform the double office of steam flues, and of pillars to support the mill-floors.

The joints of the pipes are each of the length of the height of the story where it is placed, and fit into each other by a projecting socket at the place of contact, which is stuffed in the intervals so as to be steam tight. These vertical pipes all communicate at top with a smaller horizontal pipe, which passes to the open air through the wall, where it has a valve fitted to it, opening outwards, to admit the air to pass, contained at first in the pipes; the vertical pipes all communicate at the bottom with a small horizontal copper pipe gently inclined towards the boiler, with a valve for the same purpose as that just mentioned at its upper end, outside the building, and an inverted syphon at the other end, over a hot well, from whence the boiler is supplied with water,

and into which all the hot water runs, that is formed by the condensation of the steam in the pipes. The boiler is outside the building, and communicates with the first vertical pipe near the top of the ground floor, by an inclined pipe passing through the wall from its upper part; the steam ascends through the first vertical pipe, in this apparatus, then enters the horizontal pipe at the top, from whence it descends into all the vertical pipes, forcing out the air before it as it proceeds.

The boiler, for a mill 60 feet long and 33 feet wide, is 6 feet long, 3½ broad, and 3 deep; it is fed, and managed in the usual manner; but the smoke from its fire place after passing through a short level brick flue, ascends into a cast metal pipe enclosed in a vertical brick flue, in the gable of the building; from which brick flue, small openings are made into each story a few feet above the floor; and another opening being made in it near the ground outside, a current of air, heated by the iron smoke pipe, passes from below into every apartment. The air passages may have the space of their apertures regulated by registers; and as the iron smoke pipe does not touch the fire, having a short brick flue intervening, and consequently can never be heated so as to be liable to crack, or in any other way transmit inflamed substances to the mill, there can be little or no danger of fire, while this part of the plan still further economises the heat.

The strength of the pipes, which are 3-8ths of an inch thick, renders unnecessary, valves opening inwards, as the pressure of the atmosphere cannot damage them.

This apparatus will heat the air in the rooms to 84° in the coldest season; and it is evident, that by increasing the number of pipes, and the supply of steam, any heat under 212°. may be produced.

The Society of Arts voted Mr. Snodgrass 40 guineas, or the gold medal, at his option, for this communication.

The merit of Mr. Snodgrass in the described apparatus, consists in a judicious application of well known principles, not in invention; for count Rumford, had several years ago, heated rooms by steam conveyed by pipes, as may be seen in his publication on this snbject, inserted in the Repository of Arts, vol. 15. p. 186. and elsewhere.

Mr. Green, of Wandsworth, also, in 1793, obtained a patent for warming rooms by air, heated with steam; but his method had not the same similarity to that of Mr. Snodgrass's, which count Rumford's possesses.

With respect to this plan of heating rooms, or apartments, we may remark, that it has been carried into effect in several manufacturing establishments in the United States, in one of which in particular, that of Craig, Marquedant, & Co. in the neighbourhood of Philadelphia, the plan has been successfully practised. Count Rumford long since recommended the use of steam as a vehicle for conveying heat from one place to another, by means of pipes, attached to boilers, for the purpose of dye houses, &c.

HEMP. For the growth and culture of hemp, see Agriculture. After it is prepared by breaking and hackling, it is spun into thread, whence it is made into twine, cloth, netting, &c. Besides the uses of hemp here enumerated, the refuse, called hemp sheaves, affords a fuel, and the seeds, by expression, produce an oil, which is useful to burn in lamps. On the subject of the manufactures of hemp, see Address to the Cultivators, the Capitolists, and Manufacturers in the United States, by *Tench Coxe*.

HIGGINS' BLEACHING LIQUOR. Sulphur 4 pounds, slacked lime 24b. and water 16 gallons, boiled half an hour in an iron vessel, the liquor strained off and 16 gallons more poured on the dregs and also strained off; the two solutions being mixed together and poured into 33 gallons more of water, makes a liquor of a proper standard in which cloth may be steeped in the process of bleaching, the sulphuret serving as a substitute for potash for condensing the oxy-muriatic gas. See Bleaching.

HOG. See *Animals, Domestic.*

HONEY. The most anciently used and one of the most grateful of all the saccharine juices, is a natural compound of a considerable portion of sugar, intimately mixed with several other substances that give it its slimy consistence, its peculiar colour, smell, and flavour, together with a small portion of natural acid.

Honey is found differing much in consistence and colour, being sometimes nearly as stiff as soft suet, sometimes as thin as a balsam, and of various shades of yellow, gold-colour, brown, and sometimes nearly white. The goodness of honey for culinary purposes is chiefly determined by the delicacy of flavour, but the comparative quantities of sugar and other chemical differences have not been much examined.

When honey is gently warmed over a slow fire it liquefies and a thick scum rises to the top, which when removed leaves the honey somewhat purer than before, and makes the despumated or cla-

rified honey used in pharmacy. If the honey is naturally thick it should be previously diluted with a little water. When clarified honey is slowly evaporated it becomes a thick tenacious mass, loses its delicacy of flavour, and acquires one somewhat disagreeable, becomes brown and foul, and can never by this means be made to yield crystals of pure sugar. The stronger the heat, and the browner and higher-flavoured it becomes. Whilst evaporating, a vapour rises, which takes fire at the approach of a candle and fills the house with a very strong and penetrating smell. Neuman obtained from 32 ounces of honey by distillation *per se* on a slow fire about 24 ounces of an acid watery liquor mixed with a brown oil. The residue strongly heated gave a coal difficult of incineration.

Owing to the abundant quantity both of sugar and of extract or mucilage in honey, it very readily enters into the vinous fermentation and yields a very strong wine, called *mead*, which possesses much of a honey flavour that lessens by keeping, and a very strong body. Neuman obtained a mead from 36 ounces of honey diluted with 4 quarts of warm water and fermented with yeast, which by distillation and rectification gave 8 ounces of strong alcohol.

The most interesting experiments on honey are those which have been made with a view of purifying it, and separating the truly saccharine part from every other. For the purification from its peculiar flavour which is offensive to some palates, and from the yellow colour, mere despumation and the other usual modes of clarification will not answer; Mr. Lowitz has indeed found that when diluted with water and passed through fresh burnt charcoal it lost its smell and colour, but on again inspissating it by a very gentle fire, it soon acquired its former brown colour and did not shew any tendency to crystallization. By long keeping, this honey spontaneously separated into a mass of white concrete granulated matter entangled in a viscid slime. In this state it resembled the white concrete natural honey often met with. This concrete matter was dissolved by hot alcohol, which left the other part nearly untouched. On letting the alcoholic solution stand at rest for some days a number of spherical knobs began slowly to separate, which gradually increased, forming a snow-white crust, which on being removed and dried would bear cutting with a knife into thin slices. This appeared to be the saccharine part of the honey in a considerable state of purity, but still so intimately united with some other ingredient as not to be crystallizable, as pure sugar is, but only to separate in these cauliflower-like knobs, which examined by the microscope, appeared composed of small thin longish crystals.

Mr. Lowitz also gives as characteristic differences between this white sugar of honey and common white sugar, that the former is rendered brown by lime-water, and with lime in substance and a little water a strong effervescence takes place, and the mixture becomes black, thick, and nauseous, which, clarified by charcoal and evaporated nearly to dryness, leaves a bitter yellow extract. None of these appearances take place with lime and common white sugar, neither discolouration nor decomposition being produced. The caustic fixed alkalies also produce a similar effect upon the sugar of honey, but not upon common sugar. The saccharine part of honey therefore appears most intimately combined with the extractive, and it appears probable that no direct attempts to procure pure sugar from honey will succeed, except by going through the whole process by which sugar is obtained from the cane juice. In this latter way, and with the use of claying, Neuman asserts that he has obtained a good sugar from honey resembling the fine moist sugars prepared in this way, but still not in the form of hard well-defined crystals.

Honey is often adulterated with flour, which may be detected by diffusing it in blood-warm water, by which all the honey will be dissolved and the flour remain nearly unaltered, and a subsequent boiling of the residue in the water will convert the flour into thick paste.

Honey is used only for culinary and medicinal purposes. The distilled acid spirit was formerly thought, but quite erroneously, to be a solvent for gold and silver. The same *honey-water* has the reputation of making the hair grow, and with as little foundation. See BEES.

Honey Vinegar.—This is prepared by dissolving or mixing one pound of honey in three or four quarts of water, and exposing the mixture to ferment till it becomes acid, in a temperature of between 70 and 80 degrees. The product is white.

HORN. Under the general article of horn may be iucluded (chemically considered) a great variety of tough, somewhat flexible, semitransparent organs intended by nature for defence or covering. Of this kind are the hollow horns of the ox, goat, ram, and some other animals, the hoof, the horny claw and nail, and the horny scale of certain insects and ani-

mals, chiefly cold-blooded, such as the *shell* (so called) of the tortoise. All these resemble each other very closely in chemical character, and differ considerably from some of the harder and bony defences of some animals, such as the stag's-horn, ivory, and the hard tusks of the sea-cow, and many others.

Horn (used in the above general sense) has various degrees of hardness, but is always in some degree tough and flexible, even in the cold, so that however dried, it cannot be bruised to powder as bone can. It is also distinguished from bone very remarkably, in being softened very compleatly by heat, either naked, or through the medium of water, so as then to be readily bent, moulded, and made to adhere by pressure to other pieces of horn in the same state.

No such change takes place with bone.

The valuable experiments of Mr. Hatchett, with those of preceding chemists, have also shewn a most decided chemical difference between horn and bone. When bone is boiled with water in an open vessel, (as mentioned under that article) a large quantity of *gelatin* is extracted, and the insoluble residue consists of the earth of bone, together with the albuminous cartilage, so that the texture remains unbroken. On the other hand, the different species of horn boiled with water even for many days, give to it but very little gelatin, or any other principle, but of this small portion of gelatin, the softer and more flexible horns give the most. The horn itself during the digestion, is softened considerably by the hot water, but on being taken out and dried, it becomes more brittle than at first, and in proportion to the loss of gelatin. Bone therefore contains much gelatin, and horn scarcely any.

Another difference appears after the utmost action of fire on each. When bone is burnt, a number of substances are procured, as described under that article, and the last residue is an earthy salt, chiefly phosphat of lime, amounting on an average to from half to one third of the entire weight of the bone. When horn is treated in the same way, the volatile products are indeed the same, or nearly so, but instead of a large earthy residue, scarcely any earth, or any other combustible matter remains. Bone therefore contains much phosphat of lime, but horn hardly any.

But the substance which they possess in common is that condensed tough matter, insoluble in water and weak acids, which Mr. Hatchett has so satisfactorily shewn to resemble albumen in all essential properties, and which in bone forms forms the original organic cartilage on which the earth is depositsd during the growth of the animal, and in horn forms almost the whole substance.

Horn therefore seems to consist in by far the largest proportion of condensed albumen, combined however with a small and varying portion of gelatin, which modifies its texture and flexibility, and also with a small portion of phosphat of lime.

It has been mentioned that boiling water in *open* vessels had hardly any action on horn, but when *confined in a digester*, horn as well as bone is totally soluble, because water assisted by the strong heat of a digester, will dissolve condensed albumen as well as gelatin. This method therefore is not sufficiently distinctive for chemical analysis.

The fixed alkalies readily and totally dissolve horn into a yellow saponaceous liquor.

The products obtainable from horn and bone of all kinds by distillation per se, were early attended to by chemists, as it is from these substances that a variety of valuable ammoniacal salts and preparations are obtained.

The products from bone and horn by fire are very similar, as it is only the soft parts, such as gelatin and albumen, that are decomposed in the process, the earthy phosphat remaining inert without adding to, or modifying the volatile products. These latter are a weak ammoniacal phlegm or water, on the first impression of the fire, to which succeeds an oil, thin and limpid at first, but afterwards brown and foul, and at last of a pitchy colour and consistence, and an extremely fetid empyreumatic smell. During the whole of the distillation, carbonat of ammonia comes over, partly dissolved in all the liquid products, and partly concreting on the sides of the receiver in crystalline plates. A second distillation with regulated heat is used to procure the ammonia purer: but it can hardly ever be totally freed by this means from the volatile oil; so that, though limpid and gratefully ammoniacal, the alkaline liquor or salt thus obtained, always retains somewhat of the peculiar smell of the oil, as must be observed by every one who compares the scent of common *spirit of hartshorn* with that of the pure carbonat of ammonia or *sal volatile*, which is prepared in a different way, and from other materials.

But horn (properly speaking) is seldom employed for the purpose of distillation, being too valuable as an article of manufacture to be thus sacrificed. The only

horn ever used thus is the *flag's* or *hartshorn*, which as above mentioned, partakes much more of the nature of bone, is not flexible like ox and other horn: when in shavings, readily dissolves by boiling water into a pure nutritious gelly, entangling the phosphat of lime along with it, which makes it slightly opake Stag's horn therefore is somewhat intermediate in properties between bone and true horn.

Horn and tortoise shell being applied to a number of mechanical purposes, must be cut, bent and shaped in an infinite variety of ways. This is done in most instances by the assistance of heat applied either dry, with warmed irons or burning charcoal, or by softening the horn in boiling water, and sometimes with the assistance of a weak alkaline liquor. When thus softened, one part may be made to adhere to another by mere pressure as firmly as the undivided substance Thus for example, to make the horn ring that surrounds a common opera glass, a flat piece of horn is cut out of the requisite shape, the ends intended to join are thinned down by a file, the piece is then put into boiling water till sufficiently supple, and is then rolled round a warmed iron cylinder, and held in that position by a vice, so that the ends overlap each other. Another piece of iron heated and grooved is then laid upon the seam of the joined ends, and pressed upon the cylinder, and confined there by iron wire; and the heat of the two partially melts that portion of the horn, and cements the ends so compleatly, that no seam or joining can be observed when cold.

In a similar manner, two pieces of tortoise shell may be joined together, by first neatly shaping with a file the parts that are to be united, then tying a thick paper doubled in several folds over the joining, and pressing the whole together with a hot iron instrument like curling irons, heated just sufficiently that the shell when warmed by it, will begin to bend by its own weight. When cold, the joining is perfect, and without seam. Too great heat would make the shell rise in white opake blisters, and spoil its besuty.

Horn is made to imitate tortoise shell, in the following manner: make a paste with two parts of quick-lime, one of litharge, and a little soap-makers' ley, or solution of caustic pot-ash; apply it skilfully on a thin plate of horn in a way that will best imitate the natural spots of the tortoise shell, leaving the light parts untouched; let this paste dry on, then brush it off, and the horn will be permanently stained. The effect is much improved by laying beneath it when used, a piece of brass leaf. This staining may be varied at pleasure, by substituting other coloured substances to the litharge.

To make Horn soft.—Take one pound of wood-ashes, two pounds of quick-lime, one quart of water; let it boil together to one third; then dip a feather into it, and if, in drawing it out, the plume comes off, it is boiled enough; if not, let it boil longer; when it is settled, filter it through a cloth; then put in shavings, or filings, of horn; let them soak therein three days; and, anointing your hands first with oil, work the horn shavings into a mass, and print, mould, or form it in what shape you please

To cast Horn into Moulds.—Take horn shavings as many as you will, and lay them in a new earthen pot; take two parts of wood-ashes, and the third part of lime; pour clear lye upon it, so as to cover it all over; boil it well; stir it with an iron ladle, till it has the consistence of a paste: if you will have it of a red colour, then take red lead, or vermillion, as much as you think proper, and temper it with the paste; then cast it into a mould, and let it dry: you may smooth it with a knife, and it will be of one solid piece; you may in this manner bring horn to what colour you will have it.

To prepare Horn Leaves in Imitation of Tortoise-shell, from the Laboratory.—Take of quick-lime one pound, and litharge of silver eight ounces; mix with some urine into a paste, and make spots with it, in what form or shape you please, on both sides of the horn; when dry, rub off the powder, and repeat this as many times as you will. Then take vermilion, which is prepared with size, lay it all over one side of the horn, as also on the wood, to which you design to fasten it.

For raised work, form the horn in a mould of what shape soever: put it by to dry, and with the aforesaid paste and the vermilion give it the colour; then lay on a clear glue (neither too thick, nor too thin) both upon the horn and the wood on which it is to be fixed, and close it together; do this work in a warm place, and let it stand all night; then cut, or file off, the roughness, or what is superfluous about it; rub it over with a coal, and polish it with tripoli and linseed oil.

The work made in this manner looks very beautiful and natural; and may be used, by cabinet-makers, for pillars, pilasters, pannels, or any other embellishment in cabinet-work.

Another Method to Counterfeit Tortoise-shell on Horn.—Take of good aqua-fortis two ounces, and of fine silver one drachm;

let the silver dissolve, and, after you have spotted or marbled your horn with wax, strike the solution over it; let it dry of itself, and the horn will be, in those places which are free from wax, of a brown or black colour. *Or*,

Lay the wax all over the horn; then, with a pointed skewer, or iron, draw what you will, laying the figure you draw open on the horn; then pour on the above solution; let it stand a little, and, after you have poured it off, either scrape or melt the wax; wipe it with a clean rag, and polish it.

Instead of the solution of silver, you may boil litharge of silver in a strong lye made of quick-lime, so long, till it becomes of a black tincture: or, instead of silver, you may dissolve lead in aqua-fortis.

To Solder Horn together, after it has been lined with proper Foils or Colours.—Take two pieces of horn, made on purpose to meet together, either for handles of knives, razors, or any thing else; lay foils of what colour you please on the inside of one of the horns, or, instead of foils, painted or gilded paper, or parchment; then fix the other piece upon it; lay a wet linen fillet, twice doubled, over the edges, and with a hot iron rub it over, and it will close and join together as firm as if made one piece.

HORN, to shape or bend into different forms. See Horn.

HORN, how joined. See Horn.

HORN, made to imitate tortoise-shell. See Horn.

HORN, spirit of harts. See Horn

HOROLOGY. We have taken the liberty of introducing at the request of several watchmakers, the following treatise on clock work, which, from its simplicity and usefulness, is supposed to be valuable to the practical and scientific horologist.

It is necessary first to explain the technical terms, or terms of art, and the names of the various parts of a clock and watch.

The wheels, and the rest of the work, is contained in the frame, which consists of the pillars and the plates.

That which the main-spring lies in, is the spring-box: that which the spring winds about, in the middle of the spring-box, is the spring-arbor; to which the spring is hooked at one end. At the top of the spring-arbor, is the endless-screw, and its wheel: but in spring-clocks, it is a ratchet-wheel, with its click, that stops it.

That which the main-spring draws, and about which the chain or string is wound, and which is commonly taper, is the fusee. In larger work, going with weights, where it is cylindrical, it is called the barrel: the small teeth at the bottom of the fusee, or barrel, that stop it in winding up, is the ratchet. That which stops it when wound up, and is driven up by the string, or chain, is the gardegut.

The parts of a wheel are, the hoop, or rim; the teeth; the cross; and the collet, or piece of brass, soldered on the arbor, or spindle, on which the wheel is rivetted.

A pinion is that little wheel which plays in the teeth of the wheel; its teeth (which are commonly 4, 5, 6, 7, 8, &c.) are called leaves, not teeth.

The ends of the spindle are called pivots; the holes in which they run, pivot holes.

The guttered wheel, with iron spikes at the bottom, in which the line of ordinary thirty-hour house clocks runs, is called the pulley.

The dial-plate, the hands, screws, wedges, stops, &c. hardly need mention.

Thus much for general names, which are common to all parts of a movement.

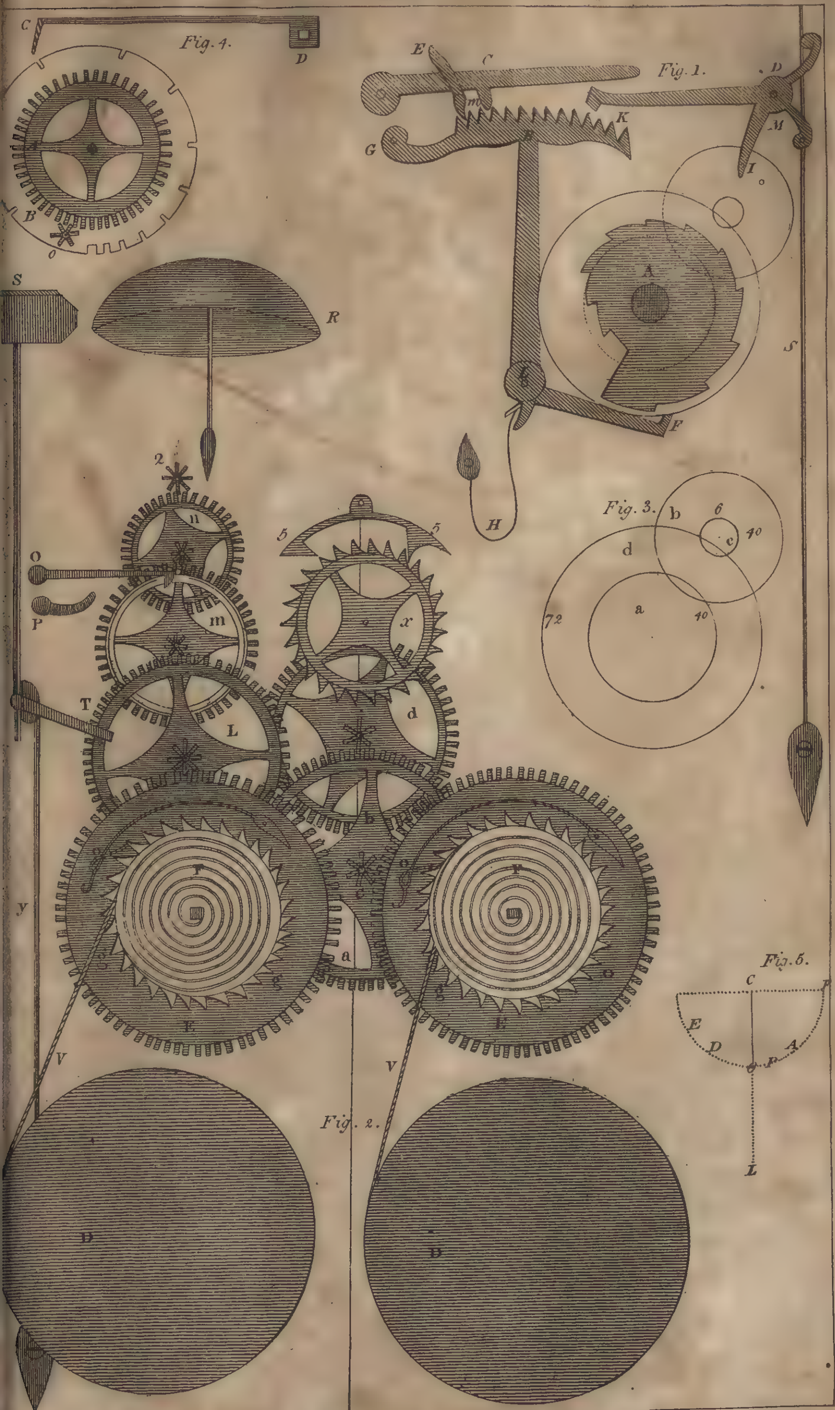
The most usual movements are watches and clocks. Watches, strictly taken, are all such movements as show the parts of time; and clocks are such as publish it, by striking on a bell, &c. But commonly, the name of watches is appropriated to such as are carried in the pocket; and that of clock to the larger movements, whether they strike the hour or not. Watches which strike the hour, are called pocket-clocks, or more commonly repeating-watches.

The parts of a movement to be considered, are the watch and clock parts.

The watch part of a movement is that which serves to measure the hours; in which the first thing to be noticed is the balance, whose parts are the rim, which is the circular part of it; the verge is its spindle to which belong the two pallets, or leaves, which play in the teeth of the crown-wheel; in pocket-watches, the strong stud in which the lower pivot of the verge plays, and in the middle of which one pivot of the balance-wheel plays, is called the pottance. The bottom of this is called the foot; the middle part (in which the pivot of the balance-wheel turns) is called the nose; the upper part, the shoulder of the pottance. The piece which covers the balance, and in which the upper pivot of the balance plays, is the cock. The small spring in pocket-watches underneath the balance, is the regulator, or pendulum-spring.

The parts of a pendulum are the verge, pallets, and cocks, as before. The ball in long pendulums, the bob in short ones, is the weight at the bottom, which is fixed to the wire or rod. The term pecu-

Clock Work. XVI



J. H. Seymour Sc.

liar to the royal swing, are the pads, which are the pallets in others, and are fixed on the arbor; the fork is also fixed to the arbor, and about six inches below, catches hold on the rod, at a flat piece of brass, called the flat, in which the lower end of the spring is fastened.

The names of the wheels next follow: the crown-wheel in small time-pieces, and the swing-wheel in royal pendulums, is that wheel that drives the balance, or pendulum.

The contrate-wheel is that wheel in pocket-watches and others, which is next to the crown-wheel, whose teeth and hoop lie contrary to those of other wheels; whence it takes its name.

The great wheel, or first wheel, is that which the fusee, &c., immediately drives. Next to it are the second wheel, third wheel, &c.

Then follows the work between the frame and dial-plate; and first the pinion of report, which is the pinion that is commonly fixed on the arbor of the great wheel, and in old watches used to have generally but four leaves; this drives the dial-wheel, which carries about the hand.

The last part to be mentioned is the clock, which is that part which serves to strike the hours; in which the great or first wheel, is that which the weight or spring first drives. In thirty-hour clocks this is commonly the pin-wheel: this wheel with pins, is called the striking wheel or pin-wheel.

Next to this striking-wheel follows the detent wheel, or hoop-wheel, it having a hoop almost round it, in which is a vacancy, at which the clock locks.

The next is the third, or fourth wheel (according as it is distant from the first wheel) called also the warning wheel.

And, lastly, is the flying pinion, with a fly, or fan, to gather air, and so bridle the rapidity of the clock's motion.

Besides these, there is the pinion of report, which drives round the locking-wheel, called also the count-wheel, with eleven notches in it commonly, unequally distant from one another, to make the clock strike the hours of 1, 2, 3, &c.

Thus much for wheels of the clock part.

The detents are those stops which, by being lifted up, or let down, lock or unlock the clock in striking.

The hammers strike the bell; the hammer tails are what the striking pins draw back the hammers by.

Latches are what lift up and unlock the work.

Catches are what hold by hooking.

The lifting pieces lift up and unlock the detents, in the clock part.

The train is the number of beats or vibrations which the watch makes in an hour, or any other certain time.

There are besides these, several other terms which clock-makers use in various sorts of pieces, as the snail or step-wheel in repeating clocks, the rack, the safe-guards, the several levers, lifters, and detents: but it would be tedious, and it is needless, to mention the particulars.

For the better understanding these terms of art, and the parts of a clock, they are represented in a plate; in which two distinct parts may be observed, the watch and the clock part.

The wheels, &c. on the right hand, is the watch part; those on the left, the clock.

D. D. (*Plate* clock-work, *Fig.* 2.) the spring boxes of the watch and clock part.

E. E. The great wheel of each part.

F. F. The fusee of each part, about which the chain or string is wound.

o. o. The click and spring of each part.

g. g. The ratchet of each part.

a. The hoop, or rim of the second wheel.

b. The cross thereof.

c. The pinion.

d. The third wheel.

x. The pallet-wheel.

L. The pin-wheel, with the striking pins e. e. e.

m. The hoop wheel.

n. The warning-wheel, or fourth wheel.

O The detent.

P. The lifting piece.

2. The fan, and flying pinion.

R: The bell.

S. The hammer.

T. The hammer-tail.

y. The hammer-spring.

V. V. The chain, or string of the watch and clock.

The pendulum consist of, 1. The rod. 2. The fork. 3. The flat. 4. The great ball. 5. The corrector, or regulator; being a contrivance of very great use to bring the pendulum to its nicest vibrations, and is fixed on the verge at the end of the pallets 5. 5.

To divide the Circumference of a Circle into any given number of equal parts, whether even or odd.—As there are very uncommon and odd numbers of teeth in some of the wheels of the astronomical clocks, and which consequently could not be cut by any common engine used by clock-makers for cutting the numbers of teeth in their clock-wheels, the follow-

ing directions are given, to shew how to divide the circumference of a circle into any given odd or even number of equal parts, so as that number may be laid down upon the dividing plate of a cutting-engine.

There is no odd number, but from which, if a certain number be subtracted, there will remain an even number, easy to be subdivided: thus, supposing the given number of equal divisions of a circle on the dividing plate to be 69, subtract 9, and there will remain 60.

Every circle is supposed to contain 360 degrees; therefore say, as the given number of parts in the circle, which is 69, is to 360 degrees, so is 9 parts to the corresponding arc of the circle that will contain them; which arc, by the rule of three, will be found to be 46.95. Therefore, by the line of chords on common scale, or rather on a sector, set off 46 94 (or 46.9) degrees with your compasses, in the periphery of the circle, and divide that arc, or portion of the circle, into 9 equal parts, and the rest of the circle into 60; and the whole will be divided into 69 equal parts, as was required.

Again, suppose it were required to divide the circumference of a circle into 83 equal parts, subtract 3, and 80 will remain. Then as 83 parts are to 360 degrees, so, by the rule of proportion, are 3 parts to 13.01 degrees; which small fraction may be neglected. Therefore, by the line of chords and compass, set off 13 degrees in the periphery of the circle, and divide that portion or arc into 3 equal parts, and the rest of the circle into 80, and the thing will be done.

Once more—Suppose it were required to divide a given circle into 365 equal parts, subtract 5, and 360 will remain; then, as 365 parts are to 360 degrees, so are 5 parts to 4 93 degrees. Therefore, set off 4.93 (or 4.9) degrees in the circle; divide that space into 5 equal parts, and the rest of the circle into 360; and the whole will be divided into 365 equal parts, as was required.

This rule or method is very useful, in dividing circles into an odd number of equal parts, or wheels into odd numbers of equal-sized teeth with equal spaces between them; and it is as easy to divide any given circle into any odd number of equal parts, as to divide it into any even number. For this purpose, the line of chords on a sector is preferable to that on a plain scale, because the sector may be opened so, as to make the radius of the line of chords upon it equal to the radius of the given circle, unless the radius of the circle exceed the whole length of the sector when it is opened, so as to resemble a straight ruler or scale; and this is what very seldom happens.

Any person who is used to handle the compasses, and the scale or sector, may very easily, by a little practice, take off degrees, and fractional parts of a degree, by the accuracy of his eye, from a line of chords, near enough the truth for the above mentioned purpose.

Supposing the distance between the centres of two wheels, one of which is to turn the other, be given; that the number of teeth in one of these wheels is different from the number of teeth in the other; and it is required to make the diameters of these wheels in such proportion to one another as their numbers of teeth are, so that the teeth in both wheels may be of equal size, and the spaces between them equal, that either of them may turn the other easily and freely; it is required to find their diameters.—Here it is plain, that the distance between the centres of the wheels is equal to the sum of both their radii in the working parts of the teeth. Therefore, as the number of teeth in both wheels, taken together, is to the distance between their centres, taken in any kind of measure, as feet, inches, or parts of an inch, so is the number of teeth in either of the wheels to the radius or semi-diameter of that wheel, taken in the like measure, from its centre to the working part of any one of its teeth.

Thus, suppose the two wheels must be of such sizes as to have their distance between their centres five inches; that one wheel is to have 75 teeth, and the other to have 33, and that the sizes of the teeth in both the wheels are equal, so that either of them may turn the other. The sum of the teeth in both wheels is 108; therefore say, as 108 teeth are to five inches, so are 75 teeth to 3.47 inches; and as 108 are to 5, so is 33 to 1.53 inches; so that, from the centre of the wheel of 75 teeth to the working part of any tooth in it, is 3.47 inches; and from the centre of the wheel of 33 teeth to the working part of either of its teeth, is 1.53 inches.

General preliminary Rules, and Directions for Calculation.—For the more clear understanding this, it must be observed, that those automata (whose calculation is chiefly intended) measure out long portions of time by little interstices, or strokes: thus the strokes of the balance of a watch measure out minutes, hours, days, &c.

Now to scatter those strokes amongst

wheels and pinions, and to proportionate them, so as to measure time regularly, is the design of calculation.

And, in the first place, any wheel being divided by its pinions, shews how many turns that pinion hath to one turn of that wheel. Thus, a wheel of 60 teeth driving a pinion of 6, will turn round a pinion 10 times in going round once. 6)60(10.

From the fusee to the balance, the wheels drive the pinions; and consequently the pinions run faster, or go more turns, than the wheels they run in; but it is contrary from the great wheel to the dial-wheel. Thus, in the last example, the wheel drives round the pinion ten times; but if the pinion drove the wheel, it must turn ten times to drive the wheel round once.

Here it will be requisite to shew how to write down the wheels and pinions, which may be done either as vulgar fractions, or in the way of division in vulgar arithmetic. For example, a wheel of 60 moving a pinion of 5, may be set down 60-5ths, or 5)60; where the uppermost figure 60, or numerator, is the wheel; the lowermost, or denominator, is the pinion; or, in the latter example, the first figure is the pinion, the next without the hook the wheel.

The number of turns which the pinion hath in one turn of the wheel, is set without a hook on the right hand, as 5)60(12; *i.e.* a pinion 5 playing in a wheel of 60, move round 12 times in one turn of the wheel.

4)36(9
———
5)55(11
5)45(9
5)40(8
———
17

A whole movement may be noted thus, $\frac{4}{36}$ $\frac{55}{5}$ $\frac{45}{5}$ $\frac{40}{5}$ 17 notches in the crown wheel; or rather, because easier to mean capacities, as in the margin, where the uppermost number above the line is the pinion of report 4, the dial-wheel 36, and 9 turns of the pin of report. The second number (under the line) is 5, the pinion, 55 is the great wheel, and 11 turns of the pinion it driveth; the third numbers are the second wheel, &c.; the fourth the contrate-wheel, &c.; and the single number 17 under all, is the number of the crown-wheel.

By knowing the number of turns which any pinion hath in one turn of the wheel it works in, you may also find out how many turns a wheel or pinion has at a greater distance, as the contrate-wheel, crown-wheel, &c.; for it is but multiplying together the quotients (by the quotients, is commonly meant the number of turns; which number is set on the right hand without the hook, as shewn in the last example), and the number produced is the number of turns. An example will make

5)55(11
5)45(9
5)40(8

this plain. Let us choose three numbers, here set down, the first of which hath 11 turns, the next 9, and the last 8. If you multiply 11 by 9, it produceth 99, for 9 times 11 is 99; that is, in one turn of the wheel 55, there are 99 turns of the second pinion 5, or the wheel 40, which runs concentrical, or on the same arbor with the second pinion 5; for as there are 11 turns of the first pinion 5, in one turn of the great wheel 55, or (which is the same) of the second wheel 45, which is on the same spindle with that pinion 5; so there are 9 times 11 turns in the second pinion 5, or wheel 40, in one turn of the great wheel 55. If you multiply the last quotient 8 (that is, 8 times 99 is 792) it shews the number of turns which the third and last pinion 5 hath; so that this third and last pinion turns 792 times in one turn of the first wheel 55. Another example will

8(80(10
6(54(9
5)40(8
———
15

make it still more plain. The example is in the margin. The turns are 10, 9, and 8. These multiplied as before, run thus, viz. 10 times 9 is 90; that is, the pinion 6 (which is the pinion of the third wheel 40, and runs in the second wheel 54) turns 20 times in one turn of the first wheel 80. This last product 90 being multiplied by 8, produces 720; that is, the pinion 5 (which is the pin of the crown-wheel 15) turns 720 times in one turn of the first wheel of 80 teeth.

A whole movement of a modern pocket Watch, may be noted thus:

The great wheel,	48	12
Centre-wheel,	54	6
Third wheel,	48	6
Contrate-wheel,	48	6
Balance-wheel,	15	2 pal.

Thus, when the watch is wound up, the chain from the spring exerts a force upon the fusee, which gives motion to all parts of the machine.

The great wheel on the fusee having 48 teeth, and driving the centre-wheel by a pinion of 12 leaves, make the centre-wheel turn round four times in one turn of the fusee. Thus also we may account for all others; for,

If 12)48(4 turns of the centre-wheel,
So 6)54(9 turns of the third wheel.
6)48(8 turns of the contrate-wheel,
6)48(8 turns of the balance.

Then multiply these several quotients together successively, and you will find the turns of each of those wheels respectively in one turn of the fusee.

Thus, 1 turn of the fusee, or great wheel; 4 mul. 1 gives 4 turns of the centre-wheel; 9 mul 4 mul. 1 gives 36 turns of the third wheel; 8 mul. 9 mul. 4 mul. 1

gives 288 turns of the cantrate-wheel; 8 mul. 9 mul. 4 mul. 1 gives 2304 turns of the balance-wheel.

And the balance-wheel having 15 teeth, and each striking a pallet twice in one revolution, there will be 30 strokes upon the axis of the balance, which are called the beats of the balance; consequently there must be 2304 mul. 30, which is equal to 69120 strokes or beats in one turn of the fusee or great wheel.

But though these particulars are necessary to be premised, the principal regard, in the division of time, is to be paid to the centre-wheel; for this wheel alone is that upon which both the hour and minute hand is moved or carried round upon the face of the watch, to shew the hour of the day, the minute of the hour, &c.

If we would find out the number of beats of the balance in the time of those turns above-mentioned, it must be noted, that as the watch goes 30 hours, and the minute hand, and consequently the centre-wheel goes round once in an hour, the said centre-wheel will have 30 turns in the time of the watch's going round; and because it hath four turns in one of the fusee, therefore we must say 4)30(7.5 the number of turns of the fusee, in winding up the watch. Whence we find 69120 mul. 7.5 equal to 518,400, the number of the beats in 30 hours. Then 30)518400(17280, the number of beats in an hour, which is termed the train of a watch; which train is said to be swifter or slower, as the number of beats in an hour is more or less: so again, if we divide this train 17280 by 3600, the seconds in an hour, the quotient will be almost 5. or nearly 5 beats per second in such a watch.

By this analysis, it is easy to form an idea of the manner of calculation for the numbers of the teeth and leaves for the several wheels and pinions in a watch; which may farther be illustrated by an example of a train 14400, which will beat quarter seconds, because such a train is useful for philosophical purposes, as well as for the just division of time.

Suppose the intended watch is to go 32 hours; then it will be found that 14400 multiplied by 32=460800=the beats of the balance in 32 hours. And if the number of turns in the fusee be 8, then 8)460800(= 57600 = the beats in one turn of the fusee.

Again, suppose the number of teeth in the balance-wheel be 15, there will be 30 beats in one turn of this wheel; then 30)57600(= 1920, which will be the number arising from the continued multiplication of all the quotients of the wheels, divided by the pinions they drive from the great wheel to the balance-wheel, as has been already exemplified.

The next care is to break this number into four convenient small numbers, which, multiplied together, shall make the same number 1920. Then say, 4(1920(— 480. Again, say, 6)480(= 80: and as 80 = 8 multiplied by 10, consequently the four numbers sought for are 4, 6, 8, and 10; because, multiply these numbers together, and they will make exactly 1920: thus 4 mul. 6 mul. 8 mul. 10 = 1920.

The quotients thus investigated, we may easily find what large numbers, divided by small ones will produce the said quotients: thus 12)48(= 4. Consequently, if we allow 48 teeth to the great wheel on the fusee, it must drive a pinion of 12 on the centre-wheel. So again, if for the quotient 6, we choose 54 and 9, thus 9)54(= 6, it shews that the teeth of the centre-wheel may be 54; and it must drive a pinion of 9 on the third wheel. Or if, instead of 54 and 9, we chuse 48 and 8, it will answer the same end: thus 8)48(= 6. Or, for the quotient 10, we may easily perceive that 50 and 5 will answer the inquiry: thus 5)50(= 10; so the third wheel having 50 teeth, must drive a pinion of 5 on the contrate-wheel: where note, that if the said wheel has 40 or 60 teeth, and drive a pinion of 4 or 6, we shall find the same number of turns exactly: and for the quotient 8, we have the number 48 and 6: thus 6)48(= 8; or, 7)56(= 8: or 5)40(= 8; therefore, if the contrate-wheel be allowed 40, or 48, or 56 teeth, it will drive a pinion of 5, 6, or 7 leaves on the balance-wheel.

This is the way to determine and adjust all the wheels and pinions in the body of a watch, from the fusee to the balance, so far as relates to the minute of an hour, and to the seconds and quarter seconds of a minute.

Having shewn the way of calculating numbers for the watch part, the principle of the striking part will next demand consideration.

Although this part consists of many wheels and pinions, yet respect needs to be had only to the count-wheel striking-wheel, and detent-wheel, which move round in this proportion; the count-wheel B (Fig. 4) moves round commonly once in 12 or 24 hours. The detent wheel moves round every stroke the clock strikes; sometimes but once in two strokes. From whence it follows,

1. That as many pins as are in the in-

wheel, so many turns has the detent-wheel in one turn of the pin wheel; (or which is the same) the pins of the pin-wheel are the quotient of that wheel, divided by the pinion of the detent-wheel. But if the detent-wheel move but once round in two strokes of the clock, then the said quotient is but half the number of pins.

2. As many turns of the pin-wheel as are required to perform the strokes of 12 hours (which are 78), so many turns must the pinion of report have, to turn round the count-wheel once. Or thus: divide 78 by the number of striking-pins, and the quotient thereof will be the quotient for the pinion of report and the count-wheel. All this is, in case the pinion of report be fixed to the arbor of the pin-wheel, as is very commonly done.

The example in the margin will explain this more clearly. Here the locking-wheel A is 48, the pinion of report is 8, the pin-wheel is 78, the striking-pins are 13; and so the rest.

8)48(6
———
6)78(13 ps.
6)60(10
6)48(8

It need only be remarked here, that 78 being divided by the 13 pins, gives 6, which is the quotient of the pinion of report O, as was before hinted; and the notches of the plate B serve to let the locking piece C fall into, which comes from the detent D.

As for the warning-wheel and flying-pinion, it matters little what numbers they have, their use being only to bridle the rapidity of the motion of the other wheels.

Numbers of several sorts of movements.—Although the directions that have been given are sufficiently plain to accomplish a young practitioner in the art of calculation, yet it may be very convenient to set down some numbers fit for several movements, partly to be as examples to exercise the young reader, and partly to serve such who want leisure to attain to the art of calculation.

Numbers of an eight day piece, with sixteen turns of the barrel: the pendulum vibrates seconds, and shews minutes, seconds, &c.

Watch part.	Clock part
8)96	8)78
8)60—40)40—6)72	7)56 8 pins.
7)56	7)49
——	7)49
30	

In the watch part, the wheel 60 is the minute-wheel, which is set in the middle of the clock, that its spindle may go through the middle of the dial-plate, to carry the minute-hand.

Also, on this spindle is the wheel 40, a, (Fig. 3), which drives another wheel b of 40; which last hath a pinion 6, c, which drives round that of 72 d in 12 hours. Note two things: 1. That the two wheels 40, are of no other use but to set the pinion 6 at a convenient distance from the minute-wheel, to drive the wheel 72, which is concentrical with the minute-wheel; for a pinion 6 driving a wheel 72, would be sufficient, if the minute-hand and hour-hand had two different centres. 2. These numbers, 60—40)40—6(72, set thus, ought, according as above, to be thus read, viz. the wheel 60 hath another wheel 40 on the same spindle; which wheel 40 divides (plays in, or turns round) another wheel 40; which has a pinion 6 concentrical with it; which pinion drives or divides a wheel of 72; for a line parting two numbers (as 60—48), denotes those two numbers to be concentrical, or to be placed upon the same spindle. And when two numbers have a hook between them (as 48) 48), it signifies one to run in the other.

In the striking part, there are 8 pins on the second-wheel 56. The count-wheel may be fixed unto the great wheel, which goes round once in 12 hours.

A piece of thirty-two days, with sixteen turns both parts: the watch shews hours, minutes, and seconds; and the pendulum vibrates seconds.

Watch part, with sixteen turns.	Striking part, with sixteen turns.
16)96	10)130
9)72	$8)96 \begin{cases} 24 \text{ pins} \\ 12)39 \end{cases}$
8)60—48)48—6)72	
7)56	6)72 double hoop
——	6)60
30	

The pinion of report is fixed on the end of the arbor of the pin-wheel. The pinion is 12, the count-wheel 39; thus, 12)39.

A Two-Months Piece of Sixty-four Days with Sixteen Turns: Pendulum vibrates Seconds, and shews Minutes, Seconds, &c.

Watch part.	Clock part.
9)90	10)80
8)76	10)65
8)60—48)48—6)72	$9)54 \begin{cases} 12 \text{ pins} \\ —8)52 \end{cases}$
7)56	
——	5)60 double hoop.
30	5)50.

Here the third wheel is the pin-wheel; which also carries the pinion of report 8, driving the count-wheel 52.

A Seven-Month Piece, with Turns, Pendulum, and Motions, as before.

Watch.	Clock.
8)60	8)96
8)56	8)88—27)12
8)48	8)64—16 pins
6)45—48)48—6)72	6)48 double hoop
5)40	6)48
30	

A Year-Piece of 384 *Days, with Turns, Pendulums, and Motions, as before.*

Watch.	Clock.
12)108	10)120
9)72	8)96—36)9
8)64	6)78 26 pins
8)60—48)48—6)72	6)72 double hoop
7)56	6)60
30	

If you had rather have the pinion of report on the spindle of the pin-wheel, it must be 13)39.

A Piece of Thirty Hours, Pendulum about Six Inches.

Watch.	Clock.
12)48	8)48
6)78	6)78 13 pins
6)60	6)60
6)42	6)48
15	

A Thirty-Hour Piece, to swing Seconds.

Watch part.	Clock part.
6)90	6)78 13 pins
6)72	6)54
	7)49
30	

Repeating-Work.

Let A be a piece of brass cut down in twelve spiral steps, in form of a snail (from whence it takes its name) as in the figure; let this be fixed on the socket of the hour wheel; and B G L F (Fig. 1) the rack, with 14 teeth, turning on its centre L, having a spring H to force the end F upon the steps of the snail A, when at liberty. The pin at I in the motion-wheel, takes hold of the lifting-piece D M K; and the end K, in rising, lifts up the hook C, which lies in the teeth of the rack, and rises until the teeth are disengaged from it; the end F then falls down, and stops against the steps of the snail A, which in the figure is at two o'clock.

The arbor of the third or 'gathering-wheel m Fig. 2) comes through the plate on which the pallet E m (Fig. 1) is fixed; a turn of which answering to one stroke of the hammer, gathers the rack up one tooth: 12 steps of tbe snail answer 12 teeth in the rack; and when the gathering pallet E m, has taken as many teeth in the rack as the number of the hour, the end E of the pallet stops against a pin in the rack at G, and is there at rest until the hook C is again lifted out of the teeth by the lifting-piece, as before.

When the hook C is lifted out of the teeth of the rack, the clock would strike continually, as the hook being out of the teeth, prevents the rack being gathered up; but that the end K of the lifting-piece has a small arm which goes through the plate, and a pin in the wheel n, which stops against it in such a manner, that when the lifting-piece is suffered to fall by the pin I, having gone past the pin in the rim of the wheel n, it is clear of the arm at the end of the lifting-piece K; the wheel being then at liberty, the clock strikes until the gathering pallet E stops against the pin of the rack at G, as before. By putting a small string to the top-end of the spring S, to come through the case, it may be made to strike the last hour at any time, except when on the warning.

In relation to this subject, we shall notice pendulums.

A Pendulum is a heavy body hanging to a small cord, or wire, which is moveable round a centre. It is that well-known instrument so useful in measuring time, and ascertaining with accuracy its nicer divisions.

A body thus suspended being put in motion, describes an arc, in one-half of which it descends, and ascends in the other.

P C (Fig. 5) is a pendulum, consisting of a body P, attached to a thread, P C, which is fastened to the point C, and is moveable round it. If the body P was let free, and not retained by the thread, it would fall in the vertical line P L: but being retained by the thread P C, it is forced to describe the arch P A, which is the segment of a circle, of which F C is the radius.

The body P acquires a velocity in falling through the P A, that has a tendency, when it arrives at the point A, to carry it off in the tangent A D; but being prevent-

ed from moving in a straight line, by the string which continually draws it towards the centre, it is forced to describe the curve A E, which, provided the pendulum were not affected by the resistance of the air, or the friction at the centre, would be exactly similar to the arch P A; that is, it would rise to the same height as it fell from. Having arrived at E, it will fall back again to A, and go on with its acquired velocity to P, and so on, continually backwards and forwards.

Each swing that it makes, is called a *vibration*, or *oscillation*.

If the pendulum vibrated *in vacuo*, and there was no friction at the point of suspension, the vibrations would not only be all equal, but they would continue for ever; but as this is not the case, the vibrations become less and less, till at last the motion totally ceases.

But it is a remarkable property of the pendulum, which was first observed by Galileo, that all the vibrations of the same pendulum, whether great or small, were performed in very nearly equal times.

The longer a pendulum is, the slower are its vibrations, and the contrary; consequently, if a pendulum be required to vibrate seconds, it must have a determinate length. This length is found to be 39.13 inches in Britain.

If a pendulum be heated, it expands, and becomes longer; consequently it vibrates slower.

Pendulums of the same length vibrate slower, the nearer they are brought to the equator, because the semi-diameter of the earth's equator is about seventeen miles longer than the axis of the earth, consequently gravity is less at the equator than at the poles; and because the centrifugal force at the equator, arising from the diurnal motion of the earth, being greater than that at the poles, lessens gravity by $\frac{1}{289}$ part. A pendulum, therefore, to vibrate seconds at the equator, must be somewhat shorter than at the poles.

When we consider a simple pendulum, or a ball suspended by a string, having no sensible weight, we suppose the whole weight of the ball to be collected in its centre of gravity, and the length of the pendulum is the distance from the centre of gravity to the point of suspension.

But when a pendulum consists of a ball, or any other figure, suspended by a metallic or wooden rod, the length of the pendulum is the distance from the point of suspension to a point in the pendulum, called the *centre of oscillation*, which does not exactly coincide with the centre of gravity of the ball.

If a rod of iron were suspended, and made to vibrate, that point in which all its force was collected, and to which, if an obstacle were applied, all its motion would cease, and be received by the obstacle, is called its centre of oscillation.

A single pendulum, consisting of a ball and a thread, whose length is two-thirds of the length of a bar without a ball, will be found to perform its oscillations in equal times with the bar. Hence, a point taken one-third of the length of the bar from the lower end, is its centre of oscillation.

The pendulums of clocks usually vibrate in the arcs of circles. It has formerly been thought an advantage to make them vibrate in the arcs of cycloids; but the difficulties that attend the practical application, are such, that there is good reason to think that they produce greater errors in the measurement of time than those they are intended to remedy.

To find the length of a Pendulum that shall make any Number of Vibrations in a given Time.

Reduce the given time into seconds, then say, as the square of the number of vibrations given is to the square of this number of seconds, so is 39.13 to the length of the pendulum in inches.

Example. Suppose it makes 30 vibrations in a minute, a minute is = 60 seconds; then,

As 900, the square of 30 : 3600 the square of 60 : : 39.13 : 156.8 inches, the length required.

If the bob of the pendulum be not a whole sphere, but a thin segment of a sphere, as in most clocks; then, to find the centre of oscillation, say, as the distance between the point of suspension and the middle of the bob, is to half the breadth of the bob, so is half the breadth of the bob to a third proportional. Set one-third of this length, from the middle of the bob downwards; which gives the centre of oscillation. Then the distance between the centres of suspension and oscillation, is the exact length of the pendulum.

Having the length of a Pendulum given, to find how many Vibrations it will make in any given time.

Reduce the time given into seconds, and the pendulum's length into inches; then say, as the given length of the pen-

dulum is to 39.13, so is the square of the time given to the square of the number of vibrations, whose square root is the number sought.

Example. Suppose the length of the pendulum is 156.8 inches, to find how often it will vibrate in a minute. 1 minute = 60 seconds. Then 156.8 : : 39.13 : : 3600 the square of 60 : 900, the square root of which is 30, the number of vibrations sought.

As heat expands, and cold contracts all metals, a pendulum-rod is longer in warm than in cold weather; and hence a source of irregularity in clocks.

Various expedients have been tried for remedying this defect; the best of which is the method of forming the pendulum of bars of brass and steel, so placed, that the expansion of one corrects that of the other, and thus preserves the centre of oscillation always in the same place. This is called the *gridiron* pendulum, from its resemblance to a gridiron.

Deal-wood is found to expand very little in the direction of the grain: hence it is much fitter for pendulum-rods than metal. Baking, varnishing, gilding, or soaking them in any melted matter, is said to render them less accurate; but rubbing on the outside with wax and a cloth, is recommended.

HORSE. See ANIMALS, DOMESTIC.

HORSE, *Disease of the.* See FARRIERY.

HORSE MEDICINES. Under this head are included those articles, or drugs, administered or applied to the horse for the purpose of curing disease; such as purges, clysters, poultices, powders, &c. See FARRIERY.

HORTICULTURE. As the system or practice of horticulture, or gardening, is extensive, embracing in itself a variety of subjects, some of which we have treated of under AGRICULTURE, we refer the reader, for every information on this branch of domestic or rural economy, to the excellent treatise of Mr *Bernard Macmahon*, who, with theoretical knowledge, extensive reading, and practical skill, has presented the world with one of the best systems which has ever appeared.

HOUSE PAINTS, are particular pigments used in painting of houses, with their appendages. The colours generally used are mentioned under COLOUR MAKING. See PAINTS.

HUSBANDRY. As this subject embraces the business of the farmer, which includes the tillage of the ground, and several other occupations, as the rearing of cattle, the making of butter, cheese, raising flax, the management of bees, &c. we refer the reader to the articles ANIMALS, DOMESTIC, AGRICULTURE, BEES, &c.

HYDRAULICS, a branch of science which treats of the motion of fluids, and their application in forming water engines of every description; such as syphons, engines, fountains, &c. See ENGINE.

We shall here describe the *diving bell* of Dr. Halley.

In order to facilitate our power of remaining on the surface of water, or of breathing when at the bottom, different methods have been contrived. As to the first, the cork waistcoat, marine spencer, &c. answers the purpose tolerably well; for the latter, the diving-bell is a well-known security. Dr. *Halley*, in a diving-bell of his own contrivance, remained fifty-two feet deep at the bottom of the sea, for the space of an hour and a half.

The diving-bell is an instrument long known and in use. That made by Dr. *Halley* was in the form of a great bell, and was coated with lead, so as to make it sink in water: it was three feet wide at top, five feet wide at bottom, and eight feet high. Into this great bell the diver entered, and sat upon a small seat withinside prepared for that purpose, and received light from a strong glass at top. Thus prepared, by means of a rope, the bell, the man, and all, were let down to the bottom, in order to search for goods, or fix cords to wrecks of ships, and such like purposes.

Though the machine is open at the bottom, and goes down many fathoms, only an inconsiderable quantity of water enters into, or rises in it, so that the diver has air enough above such water to breathe and live in for some time. This you may illustrate by an easy experiment; take a glass tumbler, and plunge it into water, with the mouth downwards and the sides perpendicular to the surface, and you will find very little water rise in the tumbler. It is the air contained therein which resists and prevents the water rising.

It is in this topmost part, which is empty, or only filled with air, that the diver keeps his head, and breathes that air which thus resists the ascending water; here he can remain for some time, living upon the condensed air, and at the same time performing what he descended for.

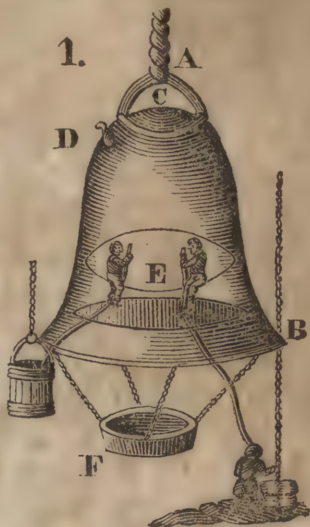
But, to be more particular in the description of Dr. *Halley's* bell. In the top

was fixed, as before-mentioned, a strong clear glass to let in the light from above, and likewise a cock to let out the hot air that had been polluted by repeated inspiration below. It was suspended to the mast of a ship, and so hoisted over the ship's side as to be let down without danger. In this, two or more divers were let down to the bottom, and two barrels of air were let down to them, to supply them with fresh air, which alternately rose and fell like two buckets. As the air from the barrels was let into the space in the bell free from water, it entered cold, and expelled the hot air, which had been spoiled, out through the cock at the top. By this method, air was communicated in such plenty, that, the Doctor informs us, that he was one of five who were together at the bottom in ten fathom of water, for above an hour and a half at a time, without any sort of ill consequence; and he might have continued there as long as he pleased, for any thing that appeared to the contrary. By the glass at the top of the bell, so much light was transmitted when the sun shone, and the sea was undisturbed, that he could see perfectly well to read and write, or to find any thing that lay at the bottom; but, in dark weather, and when the sea was rough, he found it as dark as night at the bottom. But then this inconvenience might be remedied, by keeping a candle burning in the bell as long as he pleased; for he found by experience, that a candle polluted the air by burning, just as a man would by respiring, both requiring about the same quantity of fresh air for their support, to the amount of nearly a gallon in a minute.

This mrchine was so far improved, that one of the divers might be detached to the distance of eighty or a hundred yards, by a close cap being put upon his head, with a glass in the fore part for him to see through, and a pipe to supply him with air, communicating with the great bell; this pipe was flexible, coiled round his arm, and served him as a clue to find his way back to the bell again. The only inconvenience that *Halley* complained of was, that upon their first descending, he and his companions found a small pain in their ears, as if the end of a quill were thrust forcibly through into the aperture of the ear. One of the divers, however, willing to remedy this inconvenience, stuffed his ears with chewed paper, which, as the bell descended, was so forcibly pressed into the cavities of that organ, that the surgeon could not extract the stuffing without great difficulty.

The following is a description of Dr. Halley's machine.

1.



It is about three feet wide at the top, five feet at the bottom, and eight feet high; containing about 63 cubic feet, or eight hogsheads. Its sides are loaded with lead to make it sink in the water, and on the top of the bell, C, is a thick clear glass, to give light to the machine when it is immersed: D is a stop cock, by which the impure and rarefied air is discharged: towards the middle, E, is a seat for the divers to rest upon, and a broad iron rim, F, is suspended by lines from the bottom of the bell for the men to stand upon as occasion may require.

Triedwald, a Swedish engineer, has made some improvements on this machine since *Halley's* time. That contrived by him is less than *Halley's*, and consequently more easily managed; it is illuminated with three convex glasses instead of one. It has been found, that the nearer the diver's head is to the surface of the water in the bell, the better he breathes, for the air at that place is most comfortable and cool. In *Triedwald's* bell, the diver's head is therefore nearer the water, and when there is a necessity for his lifting up his head to the top of the bell, he has a flexible pipe in his mouth, with which he breathes only the air at the surface of the water at the bottom of the bell.

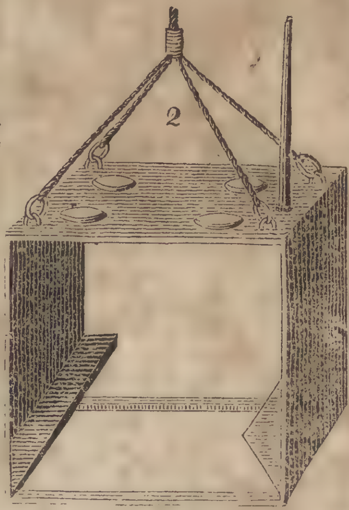
The following is a short description of

a submarine vessel, or diving machine, invented by Mr. David Bushnell, of Connecticut.

The external shape of the submarine vessel bore some resemblance to two upper tortoise shells of equal size, joined together; the place of entrance into the vessel being represented by the opening made by the swell of the shells, at the head of the animal. The inside was capable of containing the operator, and air sufficient to support him thirty minutes without receiving fresh air. At the bottom, opposite to the entrance, was fixed a quantity of lead for ballast. At one edge, which was directly before the operator, who sat upright, was an oar for rowing forward or backward. At the other edge was a rudder for steering. An aperture, at the bottom, with its valve, was designed to admit water, for the purpose of descending; and two brass forcing pumps served to eject the water within, when necessary for ascending or descending, or continuing at any particular depth.—A water guage or barometer determined the depth of the descent, a compass directed the course, and a ventilator within supplied the vessel with fresh air, when on the surface.

Of Mr. Smeaton's Diving Chest.—See the annexed figure. This machine was used with great success by Mr. Smeaton, at Ramsgate. Instead of the usual form of a bell, or of a conical tub of wood sunk by weights externally applied, Mr. Smeaton's was a square chest of cast iron. which being 50 cwt. was heavy enough to sink itself; and being $4\frac{1}{2}$ feet in height, $4\frac{1}{2}$ feet in length, and 3 feet wide, afforded room sufficient for two men at a time to work under it. It was peculiar to this machine, that the men therein were supplied with a constant influx of fresh air without any attention of theirs; that necessary article being amply supplied by a forcing air pump, in a boat upon the water's surface. The figure will give you an idea of this machine; only in the model from which the drawing was made, the sides were of glass, for the purpose of rendering the effects visible. In Mr. Smeaton's chest, light was admitted through four strong pieces of glass fitted to the upper part of the chest.

Thus we find, that scarce any part of nature is wholly secluded from human visitation, since means have been found to ascend into the aerial regions, and to descend without danger to the bottom of the ocean.

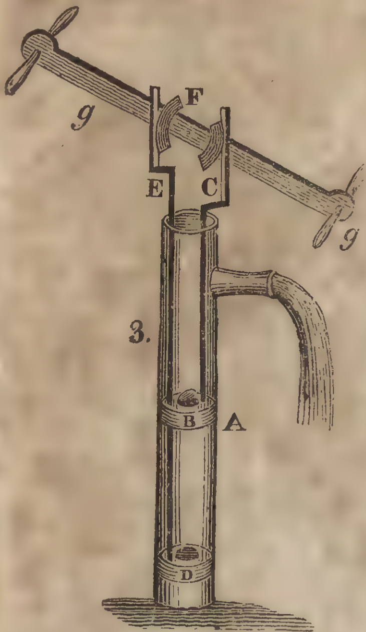


In addition to the engines for raising water, mentioned under the article Engine, we shall here insert others which appear useful.

A pump, on a construction, invented by Mr. Noble.—This pump fig. 3, deserves notice as it keeps a continual stream; being composed only of one straight pipe, or tube, and two pistons, having each a bucket and a valve. It raises as much water with the same power, and in the same time, as two barrels with four valves will do; and being simple in its principles, may be constructed at a moderate price compared with M. de la Hire's pump.

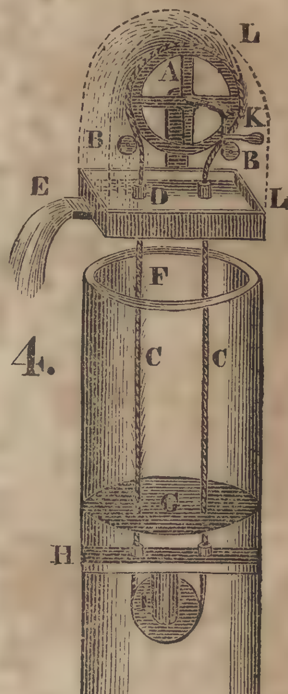
A is a straight tube, or barrel, in which two buckets work: the bucket B is worked by the rod C; and the bucket D is worked by the rod E; which rod goes through a hole in the bucket B, and is moved up and down by two circular pieces of wood F, fixed to two han-

dles gg, which causes one bucket to ascend with its load and vice versa.

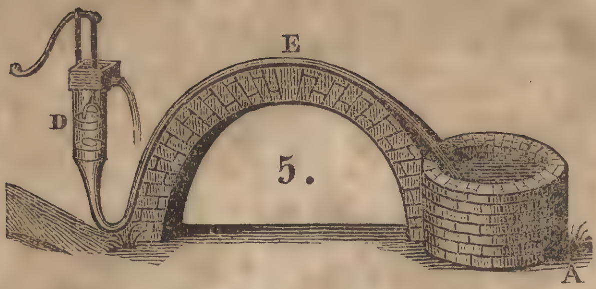


An Engine for raising water by a continual stream, by means of a hair rope. Invented by Sieur Vera.—A is a wheel 4 feet over, having an axis and a winch: B B, two pullies 14 inches diameter, in order to keep the ropes to a proper distance in the well, and be in contact with a greater surface of the wheel: C C, a hair-rope, near one inch diameter: D. a reservoir to collect the water: E, a spout to convey the water from the reservoir · F, the top of the well: G, the surface of the water in the well; H, a frame in which the lower pulley I is fixed: I, a pulley under which the rope runs, in order to keep it tight: K, the handle to turn the wheel L L L, a box made of thin boards, in order to collect the water into the reservoir D.

When the handle K is turned about with a considerable velocity, the water which adheres to the rope C C (in wells not very deep) is very considerable; the rope thus passes through the tube D, which, being 5 or 6 inches higher than the bottom of the reservoir, hinders the water from returning back into the well, and is conveyed in a continual stream through the spout E. Some of the above engines improved by Mr. Stamford, have raised a greater quantity of water than any person, unskilful in hydraulics, could suppose in the same time, from such a simple contrivance.



Of the disposition of pipes of conduit.—In some cases the pump cannot be placed conveniently perpendicular to the well; for example, being to raise water out of the well at A, fig. 5, by means of a pump at B, the best way will be to carry the barrel as low as the spring is, communicating therewith by means of the pipe at C. The bucket then playing in the barrel D C, will have the same effect as if the well was made perpendicular to the pump; because the water by its proper weight, will always replenish D C, through A, through the level of the well water at E.

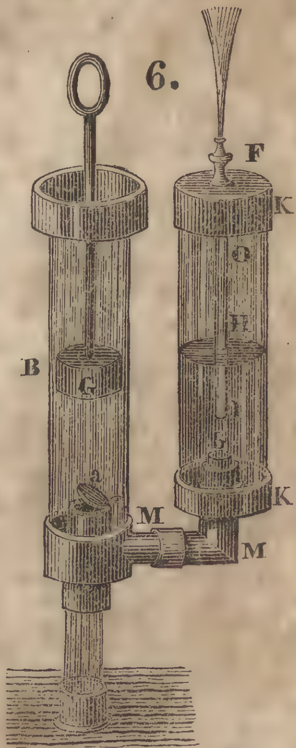


And if it should happen, from some considerable impediment, that the barrel cannot get down to the well directly, it may be led about any other way for sake of convenience. And then making the pipe of conveyance E, less in diameter than the barrel, it will sooner be exhausted of air, by moving the piston; and the water will follow very briskly, as by the leaden pump at D.

It will, however, always be more easy to draw water with pipes that are large, and of an equal bore throughout, because the water will have a less velocity in them, and the friction will be in proportion less. Upon this account, the pumps ordinarily made by the plumbers go not so easy as those bored out of trees; because, by making their pipe that brings up water from the spring so much less than the bucket, they, as it were, wire-draw the water raised. If the barrel, for instance, be four inches in diameter, and the pipe of conduit one, it will in rising move sixteen times as fast through this as it will in that, to the expence of needless labour, as well as the great wear and friction of the machine.

For the like reason, it will also be a fault to bore a pump conically upward, because the water cannot with freedom get away so fast, as a vacuum may be made in the moving piston; and the reflection of the water from the sides, will always be a hindrance to the operation.

Of the Forcing Pump, fig. 6.—It is so called, because it not only raises the water into the barrel, like the foregoing; but it afterwards forces it up into the reservoir in a lofty situation. The pipe and barrel are the same as in the other pump, but the piston, G, is solid, having no valve, so that no water can get above it. At the bottom of the barrel, B, a pipe M M, is fixed, and at right angles to this pipe, a cistern, or air vessel, K, K; at the bottom of the air-vessel there is a valve, b; from the top, a small pipe, O H I, is inserted so as nearly to reach the bottom of the air-vessel, and at the same time be air-tight at top.



The pipe-valve, a, rises when we draw

the piston up; but falls down, and stops the hole, the moment the piston is at its greatest height. Now, as the water which has been raised above this valve cannot get back again into the pipe, but has a free passage by the pipe, M M, that opens into the air-vessel, it is forced into this vessel by depressing the piston, and retained therein by its valve b, which shuts the moment the piston begins to be raised, because the pressure of the water against the under side thereof then ceases.

The water, being thus forced into the air-vessel by repeated strokes of the piston, has now got above the lower end, I, of the pipe, and begins to condense the air in the air-vessel; for the air has no way to get out of this vessel, but through the tube, O H I, of the pipe, and is prevented from escaping this way when the mouth of the tube is covered with water. It is also gradually more and more condensed as the water rises in this vessel; till at last, as you see, it presses so strongly upon the water as to force it up through the pipe O H I; from whence it spouts, at F, in a jet to a great height, and is supplied by alternately raising and depressing the piston.

The higher the surface of the water is raised in the air-vessel, the smaller is the space into which the air is condensed; and consequently, its spring will be stronger, and the pressure greater upon the water, which will be thereby driven with greater force through the pipe; and as the spring of the air continues to act even while the piston is rising, the stream will be uniform as long as the piston is worked.

The valve of the pipe opens to let the water follow the piston in rising. Whilst this valve is open, that of the air-vessel is closed, to prevent the water, which is forced into the air-vessel, from running back by its pipe into the air-vessel.

The effect of this kind of pump is not limited to the raising of water to any particular altitude; since the air's condensation may be increased to any degree.

If the air's condensation be double to that of the atmosphere, its elastic force will raise the water to about the height of thirty-four feet. If the condensation be increased three-fold, the altitude to which the water may be raised by it will be about twice the former height, or sixty-eight feet; the altitude of the raised water being increased thirty-four feet for each addition of unity to the number which expresses the air's condensation.

The engines used for extinguishing fire are upon this construction; consisting of two barrels, by which water is alternately driven into a close air-vessel. The forcing of the water therein condenses the air; which presses the water so strongly, that it rushes out with great impetuosity and force through a pipe that comes down into it, and makes a continued uniform stream by the condensation of air upon its surface.

Of a new Hand-Pump, invented by Mr. Walter Taylor, of Southampton, and used by the Royal Navy of Great Britain.

Every friend of mankind must rejoice on being informed, that the accidents to which ships that spring a leak at sea were liable from the imperfections of the chain pump, are happily removed by the ingenious contrivances of Mr. Walter Taylor, of Southampton, well known for his mechanical abilities, which, in other instances as well as in this, have proved equally beneficial to himself and to his country. It seems rather surprizing, that the common pump, whose effects are so well known, should have remained for centuries inadequate to the purposes of the navy. The mechanism adopted by Mr. Taylor is so important, and in various particulars, so different from what is in general applied to the common pump, that it may with great propriety be considered as a new invention.

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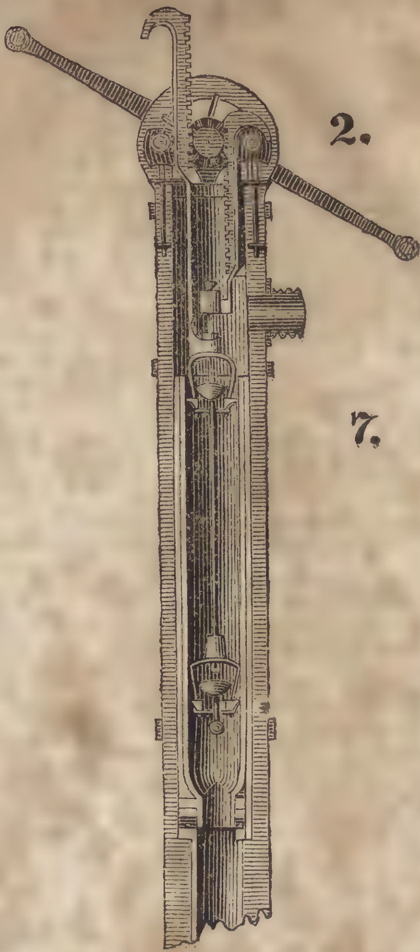

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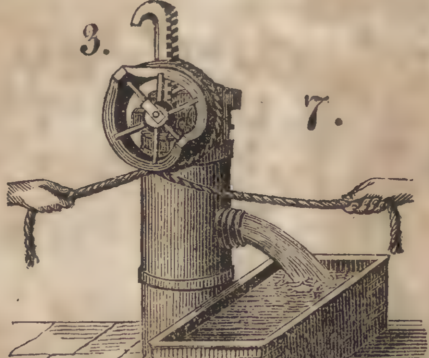

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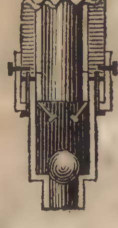

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Mr. Taylor's pumps have been in general use in the British navy for some years: they have answered every expectation he first formed, though he has made many improvements on them Here are three figures, which will give a general idea of these pumps; they are copied from drawings which were kindly communicated by Mr. Taylor. Fig. 1 is a section of one of Mr. Taylor's pumps, of a simple construction. The piston is represented as descending in a chamber properly adapted thereto. At a and b you have a view of Mr. Taylor's pendulum valves; which, from their form, disengage themselves from chips, gravel, sand, &c. The piston is also so contrived, that no chips, gravel, or sand, can get between the leather and lower part of the piston; to both which defects the former constructions were liable. Fig. 7 is a separate view of the pendulum valve.

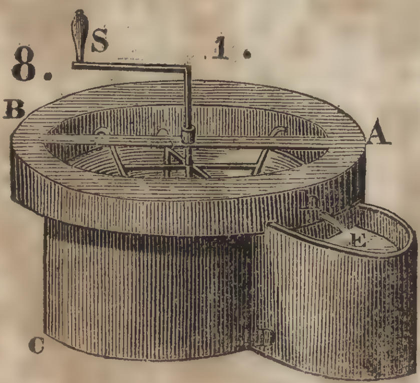
Fig. 1 represents a pump working with one piston-rod, and fig. 2 a pump working with two piston-rods, the one rising as the other falls: in fig. 1 and 2, the rods are supposed to be worked by levers. By a judicious application of ropes, to be carried on either deck, see fig. 3, Mr. Taylor is enabled, where men are plenty, as in a man of war, to raise any quantity of water. The drawing is taken from a pump with a seven-inch bore, and heaves one ton per minute twenty-four feet high, with ten men, five only working at a time. One is now constructing by Mr. Taylor, to heave five tons per minute twenty-four feet high. The pumps are also so constructed, that a copper pump may be taken out of the wooden case, in order, when necessity requires, to make two pumps for separate work.

Of the Hessian pump figures 1 *and* 2. fig. 8.

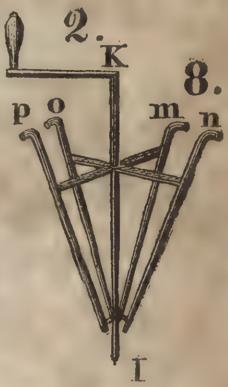
ABC, DE, two tin vessels, soldered together, but communicating with each other by a hole at bottom. The larger vessel is furnished with a rim, to receive the water thrown up by the circulating tubes, and convey it into the vessel DE; m, n, o, p, represent four tubes of metal or glass, open at both ends, but bent at top, and fixed in an angular position to the axis K L. When in their place, the extremity, L, of the axis, rests upon a point at the bottom of the large vessel, while the upper part is steadied, and kept in a vertical position, by passing through a hole in a bar going over the large vessel A B C.

Fill the vessels about two thirds with water, and then make the tubes circulate rapidly by turning the handle S, and the rotatory centrifugal motion will raise the water, and discharge it into the small vessel D E, by the pipe h.

8. 1.



2. 8.

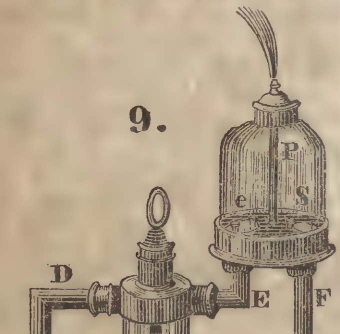


De la Hire's Pump, fig. 9.

This engine is intended to raise water as fast by the descent as by the ascent of the piston.

The pipe B is fitted to the lower end of the barrel in which the piston works. C is connected with the smaller one. There is a valve on the top of the pipes B C, and also on the two pipes E F, which proceed from the pump barrel into the air vessel P. The water is forced up B. The valves e and s lie closed at E F. As soon as the piston is as low as it can go, the valve at D closes the pipe. When the piston is raised the water is forced through E, and, after opening the valve e, into the air vessel P. (See the annexed figure.)

9.

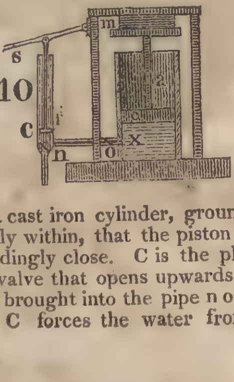


A very simple contrivance for raising water to small heights, may be effected without much friction, and without the assistance of the pump maker or plumber. The pump is formed of a square trunk, open at both ends, and having a little cistern or spout at top. Near the bottom there is a partition made of board, perforated with a hole, and covered with a clack. A long cylindrical bag or pudding, made of leather, with a fold of thin leather, such as sheep skin, between the canvass bags, is firmly raised to the board at bottom, with soft leathers between. The upper end of this bag is fixed on a round board, having a hole and valve. This board may be turned in the lathe, with a groove round its edge, and the bag fastened to it by a card bound tight round it. The fork of the piston-rod is fixed into this board: the bag is kept distended by a number of hoops or rings, placed a few inches distance from each other. Thus the bag will represent the barber's bellows-powder-puff. When this pump is put into water, and the piston forced down, it is evident that the air is driven out, and on pulling up the piston rod, the lower valve will open and the upper one close; now, as there is no communication through the lathe or bag, except by the upper valve, it is evident, that on compressing the bag, the water will pass from the bag into the pump, and by repeating the operation of raising and depressing, the water will pass out of the pipe at top. This pump is without friction, will last a long time, and will raise a considerable quantity of water. This pump is similar to the one described by Belidor, vol. 11, page 120, and some other writers on hydraulics.

The most ingenious contrivance of a pump without friction, may be found described in the works of Dr. Desgauliere, called the quicksilver pump, which is very complicated, and not much known. It is called Haskins pump. In Darwin's Phytologia, or in the Domestic Encyclopedia, may be seen a useful, though a complicated engine for raising water, called Hiero's Fountain, which is designed to raise water to a great perpendicular height, for the irrigation of land, in such situations as have the advantage of a small fall.

Water Press, fig. 10.

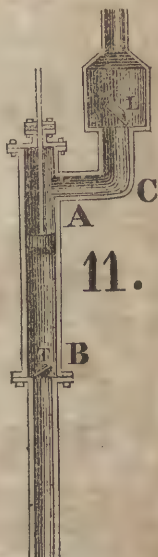
10



A is a cast iron cylinder, ground very accurately within, that the piston e may fit exceedingly close. C is the plunger, and n a valve that opens upwards. The water is brought into the pipe n o. The plunger C forces the water from n o,

through the valve X into the bottom of the cylinder, and drives up the plunger C. m represents a bundle of hay, or bag of cotton, or any other substance, which is thus brought into a compass twenty or thirty times less than it generally occupies. The power of this engine, it is obvious, depends upon the strength of the materials of which it is made, and by the force applied to it. A single man, working at S, can, by a machine of this kind, bring hay or cotton into the compass before mentioned. A press for the purpose of packing hay or cotton, is now in use in this city, not by water, but by means of screws. It is in the possession of Mr. Simmons, who, we believe, is the inventor or patentee. See ENGINES. It may be proper to mention, that a patent for a hydro-mechanical press was granted to Mr. Beverly, Dec. 26th, 1803, by the government of the United States.

The common sucking-pump may, by a small addition, be converted into a lifting-pump, fitted for propelling the water to any distance, and with any velocity. The annexed figure No. 11, is a sucking-pump whose workingbarrel A B, has a lateral pipe C, connected with it close to the top. This terminates in a main, or rising-pipe, furnished, or not, with a valve. The top of the working-barrel A B is shut by a strong plate, having a hollow neck terminating in a small flanch. The piston-rod passes through this neck, and is nicely turned and polished. A number of rings of leather are put over the rod, and strongly compressed round it by another flanch and several screwed bolts. By this contrivance, the rod is closely grasped by the leathers, but may be easily drawn up and down, while all passage of air or water is effectually prevented. The piston is perforated, and furnished with a valve opening upwards. There is also a valve, T, on the top of the suction pipe; and it will be of advantage, though not absolutely necessary, to put a valve L at the bottom of the rising-pipe Now, suppose the piston at the bottom of the working-barrel; when it is drawn up, it tends to compress the air above it, because the valve in the piston remains shut by its own weight. The air, therefore, is driven through the valve L, into the rising-pipe, and escapes. In the mean time, the air which occupied the small place between the piston and the valve T, expands into the upper part of the working-barrel; and its elasticity is so much diminished thereby, that the atmosphere presses the water of the cistern into the suction-pipe, where it rises until an equilibrium is again produced. The next stroke of the piston downwards, allows the air which had come from the suction-pipe into the barrel during the ascent of the piston, to get through its valve. Upon drawing up the piston, the air is also drawn off through the rising-pipe. Repeating this process brings the water at last into the working-barrel, and it is then driven along the rising-pipe by the piston.



11.

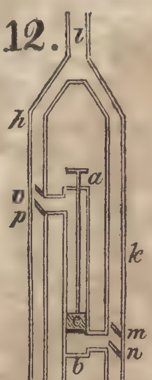
This is one of the best forms of a pump. The rarefaction may be very perfect, because the piston can be brought so near to the bottom of the working-barrel; and for forcing water in opposition to great pressures, it appears preferable to the common forcing-pump; because in that, the piston-rod is compressed and exposed to bending, which greatly hurts the pump, by wearing the piston and barrel on one side. This soon renders it less tight; and much water squirts out by the sides of the piston. But in this pump the piston-rod is always drawn, or pulled, which keeps it straight, and rods exert a much greater force in opposition to a pull than to compression. The collar of leather round the piston rod, is found by experience to be very impervious to water; and though it needs but little repair, yet the whole is very accessible; and in this respect much preferable to the common pump, in deep mines, where every fault of the piston obliges us to draw up some hundred feet of piston-rods. By this addi-

tion too, any common pump, for the service of a house, may be converted into an engine for extinguishing fire, or may be made to convey the water to every part of the house; and this without hurting or obstructing its common uses. All that is necessary, is to have a large cock on the upper part of the working-barrel, opposite to the lateral pipe in this figure. This cock serves for a spout, when the pump is used for common purposes; and the merely shutting this cock, converts the whole into an engine for extinguishing fire, or for supplying distant places with water. It is scarcely necessary to add, that, for these services, it will be requisite to connect an air-vessel with some convenient part of the rising-pipe, in order that the current of water may be continual.

It is of considerable importance, that as equable motion as possible be produced in the main pipe, which diminishes those strains which it is otherwise liable to. The application of an air-vessel at the beginning of the pipe, answers this purpose. In great works, it is usual to effect this by the alternate action of two pumps. It will be rendered still more uniform, if four pumps be employed, succeeding each other at the interval of one quarter of the time of a complete stroke.

But ingenious men have attempted the same thing with a single pump; and many different constructions for this purpose have been proposed and executed. The annexed figure represents one of the best. It consists of a working-barrel, *a b*, closed at both ends; the piston c is solid, and the piston-rod passes through a collar of leathers at the top of the barrel. This barrel communicates laterally with two pipes, *h* and *k*, the communications being as near to the top and bottom of the barrel as possible. At each of the communications are two valves, opening upwards. The two pipes unite in a larger rising-pipe at *b*; which bends a little back, to give room for the piston-rod. Suppose the piston down close to the entry of the lateral pipe *h*; when it is drawn up, it compresses the air above it and drives it through the valve in the pipe *k*, whence it escapes through the rising-pipe; at the same time it rarifies the air below it. Therefore the weight of the atmosphere shuts the valve *m*, and causes the water in the cistern to rise through the valve *n*, and fill the lower part of the pump. When the piston is pushed down again, this water is first driven through the valve *m*, because n immediately shuts; and then most of the air which was in this part of the pump at the beginning, goes up through it, some of the water coming back in its stead. In the mean time, the air which remained in the upper part of the pump after the ascent of the piston, is rarified by its descent; because the valve *o* shuts as soon as the piston begins to descend, the valve *p* opens, the air in the suction-pipe *h*, expands into the barrel, and the water rises into the pipes by the pressure of the atmosphere. The next rise of the piston must bring more water into the lower part of the barrel, and must drive a little more air through the valve *o*, namely, part of that which had come out the suction-pipe *h*; and the next descent of the piston must drive more water into the rising-pipe *k*, and along with it, most, if not all, of the air which remained below the piston, and must rarefy still more the air remaining above the piston; and more water will come in through the pipe *h*, and get into the barrel. It is evident, that a few repetitions will at last fill the barrel on both sides of the piston with water. When this is accomplished, there is no difficulty in perceiving how, at every rise of the piston, the water of the cistern will come in by the valve *n*, and the water in the upper part of the barrel will be driven through the valve *o*; and in every descent of the piston, the water of the cistern will come into the barrel by the valve *p*, and the water below the piston will be driven through the valve *m*; and thus there will be a continual influx into the barrel through the valves *n* and *p*, and a continual discharge along the rising-pipe *l*, through the valves *m* and *o*.

12.



This machine is certainly equivalent to

two forcing-pumps, although it has but one barrel and one piston; but it has no sort of superiority. It is not even more economical, in most cases; because probably, the expence of the additional workmanship will equal that of the barrel and piston, which is saved. There is, indeed, a saving in the rest of the machinery, because one lever produces both motions. It therefore cannot be called inferior to two pumps: and there is undoubtedly some ingenuity in the contrivance.

Mr Dearborn has obtained a patent from the United States for a pump, which answers as a lifting as well as forcing pump.

Chain-pump.—The chain-pump consists of two square, or cylindrical barrels, through which a chain passes, having a great number of flat pistons, or valves, fixed upon it at proper distances. This chain passes round a kind of wheel-work, fixed at one end of the machine. The teeth of this are so contrived as to receive one half of the flat pistons, which go free of the sides of the barrel by near a quarter of an inch, and let them fold in, and they take hold of the links as they rise. A whole row of the pistons, which go free of the sides of the barrel by near a quarter of an inch, are always lifting when the pump is at work, and as this machine is generally worked with briskness, they bring up a full bore of water in the pump. It is wrought either by one or two handles, according to the labour required.

The many fatal accidents which happen to ships from the choking of their pumps, make it an important object, in naval affairs, to find some machine for freeing ships from water, not liable to so dangerous a defect. The chain-pump being found least exceptionable in this respect, was adopted in the British navy; but the chain-pump itself is not free from imperfections. If the valves are not well fitted to the cylinder, through which they move, much water will fall back; if they are well fitted, the friction of many valves must be considerable, besides the friction of the chain round the sprocket-wheels, and that of the wheels themselves. To which may be added, the great wear of leathers, and the disadvantage which attends the surging and breaking of the chain. The preference therefore, which has been given to chain-pumps over those which work by the pressure of the atmosphere, must have arisen from one circumstance, that they have been found less liable to choke.

In point of friction, of coolness, and of cheapness, the sucking-pump has so evidently the advantage over the chain-pump, that it will not fail to gain the preference, whenever it shall be no longer liable to be choked with gravel and with chips.

Buchanan's pump, which, like the common pump, acts by the pressure of the atmosphere, is not liable to the defects incident to other pumps upon that principle, being essentially different from any now in use.

The principal object of its invention was to remove the imperfection of choking, and in attaining this important end, a variety of collateral advantages have also been produced, which enhance its utility.

The points in which it differs essentially from the common pump, and by which it excels, are, that it discharges the water below the piston, and has its valves lying near each other.

The advantages of this arrangement are—that the sand or other matter, which may be in the water, is discharged without injuring the barrel or the piston-leathers; so that, besides avoiding unnecessary tear and wear, the power of the pump is preserved, and not apt to be diminished or destroyed in moments of danger, as is often the case with the common and chain-pumps—that the valves are not confined to any particular dimensions, but may be made capable of discharging every thing that can rise in the suction-piece, without danger of being choked—that if there should happen upon any occasion to be an obstruction in the valves, they are both within the reach of a person's hand, and may be cleared at once, without the disjunction of any part of the pump—and that the pump is rendered capable of being instantaneously converted into an engine for extinguishing fire. Besides, it occupies very little space in the hold, and thus saves room for stowage.

But this pump is not confined to nautical uses alone; its adaptation extends to the raising of water in all situations, and with peculiar advantage where it happens to be mixed with sand or substances which destroy other pumps; as, for instance, in alum-works, in mines, in quarries, in the clearing of foundations; and in its double capacity it will be very convenient in gardens, bleaching-grounds, in stable and farm yards, and in all manufactories, or other places, where there is a necessity for raising water and the risk of fire.

With all these advantages, it is a simple and durable pump, and may be made

either of metal or wood, at a moderate expense.

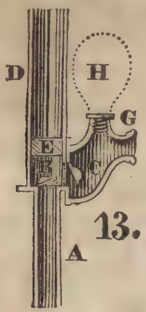


Fig. 13, is a vertical section of the pump, as made of metal, in which A is the suction-piece, B the inner valve, C the outer valve.

The valves are of the kind called *clack-valves*. Their hinges are generally made of metal, as being more durable than leather.

D the working-barrel, E the piston, G the spout.

The following parts are necessary only when the pump is intended to act as a fire-engine.

H an air-vessel, which is screwed like a hose-pipe, that it may, at pleasure, the more readily be fixed or unfixed.

There is a perforated stopple for the spout, made for receiving such pipes as are common to fire-engines. It is oval and tapered, and being introduced transversely, upon being pulled back, becomes immediately tight.

These parts being provided, all that is necessary to make the pump act as a fire-engine, after having been used as a sucking-pump, is to plug up the spout with the stopple.

No particular mode being essential in the working of this pump, it may, according to choice, or circumstances, be wrought by all the methods practised with the common pump. In many cases, however, it may be advantageous to have two of them so connected, as to have an alternate motion; in which case, one air-vessel, and even one suction-piece, might serve both.

Its principles admit of various modifications; but, as what is already mentioned, may be sufficient to indicate its superiority over the common and chain-pumps, and the advantages likely to result from its general use, a further detail is unnecessary.

To this we may add, that the testimonies of several navigators confirm in the fullest manner, the hopes that were conceived of its utility, and warrant the recommendation of it, as the best adapted for the purpose of any pump hitherto invented.

The great desideratum in a piston is, that it be as tight as possible, and have as little friction as is consistent with this indispensable quality.

The common form, when carefully executed, has these properties in an eminent degree, and accordingly keeps its ground amidst all the improvements which ingenious artists have made. It consists of a hollow cylinder, having a piece of strong leather fastened round it, to make it fit exactly the bore of the barrel, and a valve or flap to cover the hole through which the water rises. The greatest difficulty in the construction of a piston, is to give a sufficient passage through it for the water, and yet allow a firm support for the valve and fixture for the piston-rod. It occasions a considerable expense of the moving power to force a piston with a narrow perforation through the water lodged in the working-barrel. When we are raising water to a small height, such as 10 or 20 feet, the power so expended amounts to a fourth part of the whole, if the waterway in the piston is less than one-half of the suction of the barrel, and the velocity of the piston two feet per second, which is very moderate. There can be no doubt, therefore, that metal pistons are preferable, because their greater strength allows much wider apertures. For common purposes, however, they are made of wood, as elm or beech.

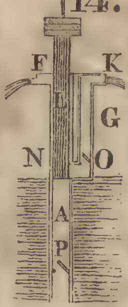
There are many ingenious contrivances to avoid the friction of the piston in the pumps; but this is of little importance in great works, because the friction which is completely sufficient to prevent all escape of water in a well constructed pump, is but a very trifling part of the whole force.

In the great pumps which are used in mines, and are worked by a steam-engine, it is very usual to make the pistons and valves without any leather whatever. The working-barrel is bored truly cylindrical, and the piston is made of metal, of a size that will just pass along it without sticking. When this is drawn up with a velocity competent to a properly loaded machine, the quantity of water which escapes round the piston is insignificant. The piston is made without leathers, not to avoid friction, which is also insignificant in such works, but to avoid the frequent necessity of drawing

it up for repairs through such a length of pipes.

If a pump absolutely without friction be wanted, the following seems preferable, for simplicity and performance, to any we have seen, when made use of in proper situations.

14.



Let NO, (*Fig.* 14,) be the surface of the water in the pit, and K the place of delivering. The pit must be as deep in water as from K to NO. A is a wooden trunk, round or square, open at both ends, and having a valve, P, at the bottom. The top of this trunk must be in a level with K, and has a small cistern, F. It also communicates laterally with a rising-pipe G, furnished with a valve opening upwards. L is a beam of timber, so fitted to the trunk, as to fill it without sticking, and is of at least equal length. It hangs by a chain from a working-beam, and is loaded on the top with weights exceeding that of the column of water which it displaces.

Now, suppose this beam to descend from the position in which it is drawn in the figure; the water must rise all round it, in the crevice which is between it and the trunk, and also in the rising-pipe; because the valve P shuts and O opens; so that when the plunger L has got to the bottom, the water will stand at the level of K. When the plunger is again drawn up to the top by the action of the moving power, the water sinks again in the trunk, but not in the rising-pipe, because it is stopped by the valve O. Then allowing the plunger to descend again, the water must again rise in the trunk to the level of K, and it must now flow out at K; and the quantity discharged will be equal to the part of the beam below the surface of the pit-water, deducting the quantity which fills the small space between the beam and the trunk. This quantity may be reduced almost to nothing; for if the inside of the trunk, and the outside of the beam, be made tapering, the beam may be let down till they exactly fit; and as this may be done in square work, a good workman may make it exceedingly accurate. But, in this case, the lower half of the beam, and trunk, must not taper; and this part of the trunk must be of sufficient width round the beam, to allow free passage into the rising-pipe; or, which is better, the rising-pipe must branch off from the bottom of the trunk. A discharge may be made from the cistern F, so that as little water as possible may descend along the trunk, when the piston is raised.

In relation to the subjects of hydraulics, the following list of patents have been granted, by the government of the United States, to sundry persons, at different times:

Elijah Ormsbee, screw engine for throwing water. March 21, 1798.

John Manning, improvement in raising water from fountains. April 10, 1798.

John Martin, regulating the action of the tide on his spiral wheel. April 27, 1798.

Mark Isambard Brunel, machine for raising water. April 27, 1798.

Isaac Lazell, machine for removing rocks, &c. May 18, 1798.

James Smallman and Nicholas J. Roosevelt, a double steam engine. May 31, 1798.

Charles Stoudingen, machine for propelling vessels. June 2, 1798.

Walter Brewster, water wheel flume for large streams. June 7, 1798.

Mark Reevee, pipes and pumps for conveying water. December 14, 1798.

Andrew Clover, machine for cleaning docks and harbours. December 14, 1798.

Joseph Huntley, machine for raising water. January 10, 1799.

Edward Reed, improvement in a horizontal water wheel. February 14, 1799.

Benjamin Tyler, a flax and hemp mill. February 26, 1799.

Josiah Shacford, improvement in propelling boats. March 21, 1799.

Samuel Morey, obtaining force from water by steam. March 27, 1799.

Samuel Morey, improvement in his water engine. April 24, 1799.

William Harris, machine for raising water. May 17, 1799.

Samuel Eli Hamlin, a capstan fire engine. August 30, 1799.

John Stickney, pumps for ships, mines, &c. November 29, 1799.

Thomas Payne, saw mill. December 2, 1799.

Patrick Lyon, engine for throwing water. February 12, 1800.

Aaron Brookfield, raising water for mills. October 24, 1800

Samuel Murray, obtaining force from water by the assistance of steam. November 17, 1800

John Strong, hydraulic engine. March 24, 1801.

John Eveleth, forcing pump. June 13, 1801.

William Palmer, machine for raising water. August 25, 1801.

John Poole, syphonic steam machine. October 13, 1801.

Hezekiah Richardson, junior, and Levi Richardson, improvement in a saw mill. April 28, 1802.

Jacob Perkins, improvement in pumps. July 9, 1802.

Samuel Briggs, junior, improvement in a steam engine October 9, 1802.

John Baptiste Aveilhe, a machine for raising water. (A perpetual motion!!!!!!) October 4, 1802.

James Cowen, improvement in the construction of mill wheels. December 14, 1802.

Elisha Rigg, improvement in the method of making pumps. July 29, 1794.

Benjamin Wynkoop, a new mode of propelling vessels. September 13, 1794.

Joshua Hathway, improvement in hydraulics. October 29, 1794.

Frederic Lipart, a machine for raising water from a running stream. 1805.

Benjamin Tomlinson, a machine for raising and projecting fluids. May 27, 1805.

William Tin, a spring pump for raising water. February 13, 1805.

Jacob Smith, junior, an improvement in the fire engine. May 20, 1805.

Daniel Watson, an improvement in the common suction pump. March 4, 1808.

Edward Lady, junior, a firing pump with double actions, applied to engines. March 9, 1808.

John Johnson, a wheel to run under water. March 21, 1808.

Isaac Stilwell, apparatus for propelling boats by the force of the current. June 3, 1808.

David Burt, a hydrant for drawing water for aqueducts. June 22, 1808.

Richard Ramsy, an improvement in making conduit pipes, &c. from clay. June 24, 1808.

Besides these, other patents have been obtained for hydraulic engines, and instruments connected with hydraulics, both in America and Europe. An enumeration of the latter may be seen in the *Repertory of Arts*.

HYDRAULICS, ABSTRACT OF—1. *Hydraulics* teaches the laws of fluids in *motion*.

2. The *velocity* of spouting fluids, is as the square root of the depth of the orifice below the surface

3. Water in bended pipes always rises as high as the *source* from whence it springs: hence the construction of jets, or fountains, and the supplying of towns with water.

4. A *syphon* is a bended pipe of unequal legs. The cause of its action in emptying vessels, is owing to the pressure of the atmosphere added to the preponderance of weight in the longest leg.

5. *Pumps* for raising water are of three kinds: the *sucking*, *forcing*, and *lifting* pump.

6. The water in a sucking-pump is raised from the well by the *pressure of the atmosphere;* and it can be raised by this means only 33 feet.

7 A *lifting* pump, not depending upon this, may raise the water to any height, according to the power applied.

8. A *forcing* pump is also unlimited, in regard to the height to which it may raise water.

9. An *air-vessel* is added to a forcing-pump, to give a more *equable stream*.

10. A constant stream is also produced by *two* barrels, with pistons moving up and down alternately.

11. The *chain-pump* also produces the same effect, and has very little friction.

12. Buchanan's *pump* is superior to the chain-pump, and is one of the best yet invented.

13. There are many contrivances to avoid friction in pumps; but in great works, the friction of the piston is of little importance.

14. *Plungers*, are pistons that nearly fill the working-barrel: these do not act upon the principle of the pressure of the atmosphere.

15. Valves in pumps are of various constructions: the most usual and best are the *clack* valve, the *button* and *tail* valve, the *conical* valve, and the *globular* valve.

16. It is immaterial whether a pump be

placed perpendicular to the well or not provided it have a communication with i by pipes.

17. In pump-work, all contractions, or sudden enlargements, in the pipes, should be avoided

18. The steam-engine was originally invented by the marquis of Worcester, but was first put in practice to any extent, by captain Savary.

19. Savary's engine had no lever, but acted by the immediate pressure of the steam upon the water.

20. Newcomen improved it, by adding a lever, or beam, and attaching to it a piston which worked in a cylinder. Upon this piston the pressure of the atmosphere is made to act, by forming a vacuum underneath it.

21. Mr. Watt improved the cylinder, by surrounding it with bad conductors of heat; and this prevented a waste of steam, by cooling.—He also condensed the steam, to form the vacuum under the piston, in a separate vessel. Instead of depressing the piston by the pressure of the atmosphere, he used the force of steam introduced above it, while the piston was raised up again by the load at the other end of the beam. His last improvement, is the *double steam-engine;* in which the piston is forced both up and down, by the immediate pressure of the steam.

With respect to the improvements which have been made on the steam engine, in this country, by *Oliver Evans* and others, we shall notice them under the article STEAM ENGINE.

HYDROCARBURET, or carbonated hydrogen gas. The only use made of this gas, is for the purpose of lighting rooms, houses, manufactories, &c. by inflaming it, and is known under the name of the *gas light,* which see. The species of hydrocarburet used for this purpose, is that obtained from pit coal, although the same has been obtained for the same use from wood by destructive distillation. Dr. Kughler informs us, that the gas obtained from ligneous substances, gave a better and a clearer light, without the inconvenience of tan, than that from pit coal. See GAS LIGHT.

HYDROMEL or *mead,* is a fermented liquor made of honey and water. It is generally prepared in the following manner: Put 90 pounds of honey into 30 gallons of water, boil the mixture or solution, taking care to separate the scum; remove it, and put it into a barrel, and add 2 ounces of ginger, half an ounce of cinnamon, and the same quantity of pimento; add a small portion of yeast, and let it ferment, after which bottle it for use. Mead was the favourite beverage of the ancient Britons and Anglo-Saxons. As it contains a large quantity of carbonic acid, it is extremely wholesome, and if mixed with a little soda will form a substitute for *soda water,* sold in our city.

HYDROMETER. This is an instrument principally used by brewers and distillers to determine the strength of their liquors.

The neck A B is a piece of brass, or any other metal which is graduated, to show the different depths to which the instrument descends in different gravities of fluids, B is a brass bulb to which the neck is fastened: and C is a weight which is sometimes hung from the bottom to keep the instrument in an erect position when the bulb is immersed in the fluid; and at A is a small shoulder to receive the weights which are laid on the instrument, to adjust it to any particular depth on the graduated neck.

Now, as the resistance of fluids is according to their density, it is obvious that the instrument will sink deepest in those fluids that are the lightest, and this variation is shown by the scale or neck. When the instrument is immersed, the fluid which is displaced by it is equal in bulk to that part of the instrument which is covered by the water, and in weight to the whole instrument. Then, supposing its weight to be 4000 grains, the different bulks of fluids containing the weight of 4000 grains may be compared, so that if a difference of one tenth of an inch take place in the neck by immersing it in

two different fluids, it shows that the same weight of the liquors differs in bulk by the magnitude of one tenth of an inch of the stem of the instrument.

The specific gravity of fluids may be found by putting an ounce, or any other weight, of distilled water into a glass phial, and marking the height; then empty the bottle and fill it up to the same height exactly with any other fluid, and weigh them both in a nice balance; the difference of these weights will be the difference of their specific gravities, for their bulks are equal.

The following observation on the hydrometer are given by Nicholson: The best method of weighing equal quantities of corrosive volatile fluids, to determine their specific gravities, appears to consist in inclosing them in a bottle with a conical stopper, in the side of which stopper a fine mark is cut with a file. The fluid being poured into the bottle, it is easy to put in the stopper, because the redundant fluid escapes through the notch, or mark, and may be carefully wiped off. Equal bulks of water, and other fluids, are by this means weighed to a great degree of accuracy, care being taken to keep the temperature as equal as possible, by avoiding any contact of the bottle with the hand, or otherwise. The bottle itself shows with much precision, by a rise or fall of the liquid in the notch of the stopper, whether any such change have taken place. See SPECIFIC GRAVITY.

But as the operation of weighing requires considerable attention and steadiness, and also a good balance, the floating instrument called the hydrometer has always been esteemed by philosophers, as well as men of business. It consists of a hollow ball, either of metal or glass, capable of floating in any known liquid: from the one side of the ball proceeds a stem, which terminates in a weight, and from the side diametrically opposite proceeds another stem, most commonly of an equal thickness throughout. The weight is so proportioned, that the instrument may float with the last mentioned stem upright. In the less accurate hydrometers this stem is graduated, and serves to show the density of the fluid, by the depth to which it sinks; as the heavier fluids will buoy up the instrument more than such as are lighter. In this way, however, it is clear, that the stem must be comparatively thick, in order to possess any extensive range. For the weight of vitriolic ether is not equal to three fourths of the same bulk of water; and therefore such an hydrometer, intended to exhibit the comparative densities of these fluids, must have its stem equal in bulk to more than one fourth of the whole instrument. If this bulk be given chiefly in thickness, the smaller differences of density will not be perceptible, and it cannot, with any convenience, be given in length.

To remedy this imperfection, various contrivances have been proposed for the most part grounded on the consideration, that a change in the ballast, or weight employed to sink the ball, would so far change the instrument, that the same short range of graduations on a slender stem, which were employed to exhibit the densities of ardent spirit, might be employed in experiments upon water. Some have adjusted weights to be screwed upon the lower stem; and others, with more neatness and accuracy, have adjusted them to be slipped upon the extremity of the upper stem. But the method of Fahrenheit appears to be on all accounts the simplest and most accurate.

The hydrometer of Fahrenheit consits of a hollow ball, with a counterpoise below, and a very slender stem above, terminating in a small dish. The middle, or half length of the stem, is distinguished by a fine line across. In this instrument every division of the stem is rejected, and it is immersed in all experiments to the middle of the stem, by placing proper weights in the little dish above. Then as the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known; this last weight added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, as all writers on hydrostatics prove. And accordingly the specific gravities for the common form of the tables will be had by the proportion:

> As the whole weight of the hydrometer and its load, when adjusted in distilled water,
> Is to the number 1,000, &c.
> So is the whole weight when adjusted in any other fluid
> To the number expressing its specific gravity.

In order to show the degree of accuracy an instrument of this kind is capable of, it may in the first place be observed, that the greatest impediment to its sensibility arises from the attraction or repulsion between the surface of the fluid and that of the stem. If the instrument

be carefully wiped with a soft clean linen cloth, the metallic surface will be equally disposed to attract or repel the fluid. So that if it possess a tendency to descend, there will be a cavity surrounding the stem; or if, on the contrary, its tendency be to rise, the fluid will stand round the stem in a small protuberance. The operator must assist this tendency, by applying the pincers, with which he takes up his weights, to the rim of the dish. It is very easy to know when the surface of the fluid is truly flat, by observing the reflected image of the window, or any other fit object seen near the stem in the fluid. In this way the adjustment of the weights in the dish may, without difficulty, be brought to the fiftieth part of a grain. If, therefore, the instrument displace 1000 grains of water, the result will be very true to four places of figures, or even to five. This will be as exact as most scales are capable of affording.

Some writers have spoken of the adjustment of an hydrometer of this kind, so that it shall at some certain temperature displace 1000 grains of water, as if this were a great difficulty. It is true, indeed, that the performance of a piece of workmanship of this nature would require both skill and judgment on the part of the artist: but it is by no means necessary. Nothing more is required on the part of the workman, than that the hydrometer shall be light enough to float in ether, and capable of sustaining at least one third of its own weight in the dish, without oversetting in a denser fluid. This last requisite is obtained by giving a due length to the stem beneath, to which the counterpoise is attached. With such an instrument, whatever may be its weight, or the quantity of water it displaces, the chemist may proceed to make his experiments, and deduce his specific gravities by the proposition before laid down. Or to save occasional computation, he may once for all make a table of the specific gravities, corresponding to every number of the load in the dish, from one grain up to the whole number of grains, so that by looking for the load in one column, he may always find the specific gravity in the column opposite. We find this method very ready and convenient in practice: but, if it be preferred, the weights may be adjusted to the hydrometer, so as to show the specific gravity, without computation or reference. For this purpose the hydrometer must be properly counterpoised in distilled water, at the assumed standard temperature; suppose 60°, and the whole weight of the instrument and its load called 1.000, &c. Then the weight of the instrument and its load must be separately determined in grains and parts, or other weights, by a good pair of scales. And as the whole weight of the instrument and its load is proportioned to the weight of the instrument alone; so will be the number 1.000, &c. to a fourth term expressing the weight of the instrument in such parts as make the whole 1.000, &c. Make an actual set of decimal weights of which 1.000, &c. shall be equal to the hydrometer and its load. And it is clear, that, whatever may be the load in these weights, if it be added to the number denoting the weight of the instrument, the sum will denote the specific gravity of the fluid, wherein the instrument floats with that load.

By following the above easy method it will be found, that every hydrometer, wheresoever made, must give the same results. The subject is indeed in itself sufficiently simple, and would require scarcely any discussion, if it had not happened, that many philosophers, for want of requisite attention, have made their experiments with hydrometers graduated on the stem by no certain rule by which operators at a distance from each other might compare their experiments. The hydrometers, or *pese-liqueurs* of Baumé, though in reality comparable with each other, are subject in part to the defect, that their results, having no independent numerical measure, require explanation to those who do not know the instruments. Thus, for example, when a chemist acquaints us, that a fluid indicated 14 degrees of the *pese-liqueur* of Baumé we cannot usefully apply this result, unless we have some rule to deduce the correspondent specific gravity: whereas we should not have been in any respect at a loss, if the author had mentioned the specific gravity itself. As a considerable number of French philosophors refer to this instrument, it will be of use to explain its principles.

Mr. Baumé appears to have directed his attention chiefly to the acquisition of a means of making hydrometers with a graduated stem, which should correspond in their results, notwithstanding any differences in their balls or stems. There is little doubt but he was led into the method he adopted, by reflecting on that by which thermometers are usually graduated (see THERMOMETER.) As thermometers are graduated, independent of each other, by commencing with an interval between two stationary points of temperature, so Mr. Baumé adopted two determinate densities for the sake of

marking an interval on the stem of his hydrometer. These densities were those of pure water, and of water containing $\frac{15}{85}$ parts of its weight of pure dry common salt in solution. The temperature was 10 degrees of Reaumur above freezing, or 54.5° of Fahrenheit. His instrument for salts was so balanced, as nearly to sink in pure water. When it was plunged in this saline solution, the stem arose in part above the surface. The elevated portion was assumed to be 15 degrees, and he divided the rest of the stem with a pair of compasses into similar degrees.

It is unnecessary to inquire in this place, whether this interval be constant, or how far it may be varied by any difference in the purity, and more especially the degree of dryness, of the salt. Neither will it be requisite to inquire how far the principle of measuring specific gravities by degrees representing equal increments, or decrements, in the bulks of fluids, of equal weight but different specific gravities, may be of value, or the contrary. It does not seem probable, that Baumé's instrument will ever become of general use; for which reason nothing further need be ascertained, than the specific gravities corresponding with its degrees, in order that such experiments as have this element among their data may be easily understood by chemicall readers.

Mr Baumé, in his Elemens de Pharmacie, has given a table of the degrees of his hydrometer for spirits, indicated by different mixtures of alcohol and pure water, where, he says, the spirit made use of gave 37 degrees at the freezing point of water; and in a column of the table he states the bulk of this spirit, compared with that of an equal weight of water, as thirty-five three-eights to thirty. The last proportion answers to a specific gravity of 0.842, very nearly. As a mixture of two parts, by weight, of this spirit, with thirty of pure water, gave twelve degrees of the hydrometer at the freezing point. This mixture, therefore, contained 6½ parts of Blagden's standard to 100 water; and, by Gilpin's excellent tables, its specific gravity must have been 0.9915. By the same tables, these specific gravities of 0.842 and 0.9915 would, at 10° Reaumur, or 55° Fahr. have fallen to 0.832 and 0.9905, Here then are two specific gravities of spirit corresponding with the degrees 12 and 37, whence the following table is constructed.

Beaumé's Hydrometer for Spirits.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
10 =	1.000	17 =	.949	23 =	.909	29 =	.874	35 =	.842
11 =	.990	18 =	.942	24 =	.903	30 =	.868	36 =	.837
12 =	.985	19 =	935	25 =	.897	31 =	.862	37 =	.832
13 =	.977	20 =	928	26 =	.892	32 =	.857	38 =	.827
14 =	.970	21 =	.922	27 =	.886	33 =	.852	39 =	822
15 =	.963	22 =	.915	28 =	.880	34 =	.847	40 =	.817
16 =	.955								

With regard to the hydrometer for salts, the learned author of the first part of the Encyclopédie, Guyton-de-Morveau, who by no means considers this an accurate instrument, affirms, that the sixty-sixth degree corresponds nearly with a specific gravity of 1.848; and as this number lies near the extreme of the scale, I shall use it to deduce the rest.

Beaumé's Hydrometer for Salts.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.	Deg.	Sp. Gr.
0 =	1.000	15 =	1.114	30 =	1.261	45 =	1.455	60 =	1.717
3 =	1.020	18 =	1.140	33 =	1.295	48 =	1.500	63 =	1.779
6 =	1.040	21 =	1.170	36 =	1.333	51 =	1.547	66 =	1.848
9 =	1.064	24 =	1.200	39 =	1.373	54 =	1.594	69 =	1.920
12 =	1.089	27 =	1.230	42 =	1.414	57 =	1.659	72 =	2.000

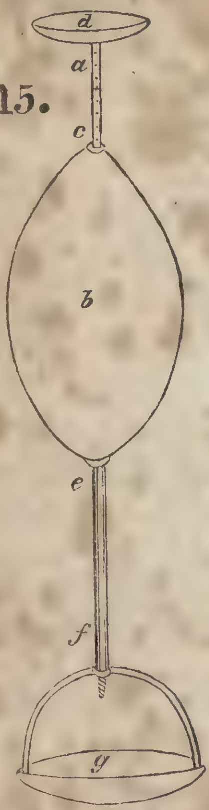
It may not be amiss to add, however, that in the Philosophical Magazine, Mr. Bingley the asay-master of the mint, has given the following numbers as the specific gravity of nitric acid found to answer to the degrees of an areometer of Baumé by actual trial; temperature about 60° Fahr. But his appears to have been a different instrument, as it was graduated only from 0 to 50.

Deg. Sp. Gr.	Deg. Sp. Gr.	Deg. Sp. Gr.	Deg. Sp. Gr.	Deg. Sp. Gr.
18 = 1.150	29 = 1.250	34 = 1.300	38 = 1.350	42 = 1.400
20 = 1.167	30 = 1.267	35 = 1.312	39 = 1.358	43 = 1.416
26 = 1.216	31 = 1.275	36 = 1.333	40 = 1.367	45 = 1.435
28 = 1.233	32 = 1.283	37 = 1.342	41 = 1.383	

There are a variety of hydrometers used for determining the strength of ardent spirit. See an essay of the Editor, on specific gravity, 8vo.

The following is a description of Mr. G. Atkins's hydrometer for determining the specific gravity of both solids and liquids, which we insert from a belief that it will be extremely useful.

15.



The hydrometer consists of the bulb *b*, a small stem *a c*, with a cup *d* on its top to receive weights, and a shank *e f* beneath the bulb with a pointed screw, to which is affixed a cup *g*, to receive weights or solids when their specific gravities are required to be taken.

The instrument is accompanied with an accurate set of grain weights.

The weight of the hydrometer itself is seven hundred grains, and on adding three hundred grains in the *upper cup*, and immersing it in distilled water, at the temperature of 60 degrees of Fahrenheit's thermometer, it will subside to the middle mark on the stem, and will then consequently displace one thousand grains of water.

It follows, therefore, from this adjustment of the bulk of the instrument, that each grain in the upper cup will represent one thousandth part of the specific gravity of the water, or one unit in specific gravity, if that of water be taken to be one thousand; and one-tenth of a grain one-tenth of a unit, which is also the value of each of the small divisions on the stem; and accordingly, when the hydrometer is immersed in any liquid until it sinks to the middle point on the stem, the specific gravity of such fluid will be indicated by the sum of the weight of the instrument (which is, as before stated, seven hundred grains) and the grains added in the upper cup.

Suppose, for example, that, on immersing the instrument in ether, it requires thirty-four grains in the top cup to make it subside to the middle mark on the stem. The specific gravity of such ether will in this case be $700+34=.734$. And on putting the instrument into alcohol or wort, if it requires in the former case one hundred and twenty-five grains, and in the latter three hundred and fifty-five, the specific gravity of the spirit will be .825, and that of the wort 1.055.

To ascertain the specific gravity of a solid, we have to take any fragment less than three hundred grains; find its weight in air, and its weight in water, and take their difference; and on dividing its weight in air by this difference the quotient will be its specific gravity.

The weight of a body in air is found by

putting it in the *upper cup*, and adding grains until the hydrometer sinks in water to the mark on the stem. Now, as the substance and the additional weights in the cup will be altogether three hundred grains, the weight of the body will of course be so many grains as the weights put in fell short of three hundred. Its weight in water will be found by putting it into the *lower cup*, and adding grains in the *upper cup* until the instrument sinks as before: the complement of the weights in the top cup to three hundred being in like manner its weight in water.

Example.—If a body weighs in air one hundred and twenty grains, and in water one hundred and four, the difference is sixteen. On dividing one hundred and twenty by sixteen, we have for the quotient .75, or (taking, as before, the specific gravity of water at one thousand) 7.500 for the specific gravity of the body.

This instrument affords us consequently a very ready mode of determining the purity or value of any alloy or metallic ore, and is therefore particularly adapted to the mineralogist. Thus, for example, the weight of a guinea, or its weight in air, is one hundred and twenty-eight grains; and if the gold is of its proper standard, it will weigh about one hundred and twenty-one grains in water, or will lose one-eighteenth part *only* of its weight in air. If it loses more, therefore, it is not of its proper specific gravity, and consequently not of standard gold.

To find the specific gravity of any of the different species of wood or other bodies lighter than water;—after taking its weight in air as before, fix it on the small screw of the shank, and see how many grains it will then be necessary to add in the top cup, to sink the instrument to the mark, with the body on the screw; which will in this case be more than three hundred, on account of its buoyancy; and dividing its weight in air by the difference between the weights put in the top cup in each case, the quotient will be its specific gravity.

Thus, if on putting a piece of *willow* in the upper cup, it requires two hundred and fifty-eight grains to sink the hydrometer in water, the weight of the wood in air will be forty-two grains: and if on fixing it to the screw beneath, the instrument requires three hundred and twenty-eight grains to sink it to the mark in water, (being twenty-eight grains more than would be necessary to sink the instrument itself,) we have only to find the difference between the weights put into the top cup, which in this case is seventy grains; and dividing forty-two by seventy, we have .6 or .600 for the specific gravity of the wood.

For the man of science, the instrument with its set of weights is all that is necessary, and it is packed into a very small compass; but to accommodate it to those who are concerned with spirituous liquors, and to brewers, the inventor attaches a scale, showing the relation between specific gravities and the commercial or technical denominations of *per centage* with the former, and *pounds per barrel* with the latter.

It is needless to enumerate the various departments in which an attention to the specific gravities of bodies is now become of the first consequence, and wherein this instrument might be applied with advantage; and although many may be satisfied if they have any arbitrary standard to regulate their process by, yet it must be acknowledged that the universal standard of *specific gravity* is by far the best; for, by its currency all over Europe, it enables a person to know what relation their practice may bear to that of others in the same pursuit; and it would, by the universal adoption of it, prevent the many differences which exist among mercantile men, especially those who deal in, or pay duty on, spirituous liquors.

Indeed the wide field which opens, on considering the importance of paying attention to the specific gravity of bodies, convinces us that we are yet in infancy on the subject.

HYDROSTATICS, a branch of natural philosophy, which treats of the motion, pressure, and equilibrium of fluids, and also, of the art of weighing solids in them, to determine the different specific gravities or relations of bodies to one another.

HYDROSTATICS, abstract of. 1. Hydrostatics treats of the *mechanical* properties of *non-elastic* fluids, such as water.

2. The *cause* of fluidity is not perfectly known; but it cannot be owing to any particular configuration of particles, since fluids and solids are convertible into each other by adding or subtracting heat.

3. A portion of fluid gravitates in another, when surrounded by a larger portion, in the same way as if it were in the air.

4. Fluids press *in all directions* equally.

5. A fluid presses in proportion to its perpendicular height, and the base of the vessel containing it, without any regard to the quantity.

6. By *specific gravities*, is meant the relative weights of equal bulks of different substances.

7. This relative weight is generally compared with an equal bulk of *water*, as a standard.

8. The instrument for comparing these weights of solids, is called the *hydrostatic-balance*.

9. That for comparing the specific gravities of liquids, is called the *hydrometer*.

10. Air-balloons rise in the atmosphere, because they are specifically lighter, or lighter than an equal bulk of air.

11. They are of two kinds—*fire-balloons*, and *inflammable-air* balloons.

12. The diving-bell is an empty vessel inverted, and made so heavy as to sink in water.

Hydrostatic Balance. See *Specific gravity*.

I.

ICE. See FREEZING.

ICE CREAM. This preparation, which is only a delicacy, is usually made by confectioners, by mixing about three parts of cream with one part of the juice or jam of raspberries, currants, &c. and is frozen in the following manner: Strain the mixture through a cloth, and introduce it into a pewter mould or vessel, and introduce the mould or ice pot, with its contents into ice and salt. Agitate the mould in this mixture for a few minutes, and the cream will be frozen. The principle on which the freezing of cream takes place, is the same as the freezing of water; the use of salt with the ice, is intended to form an artificial cold, or freezing mixture, in order to expedite the process. The ice absorbs the caloric of fluidity from the cream, and becomes liquefied, by which the cream is rendered solid.

ICE-HOUSE, a receptacle for ice, in order to preserve it in the summer months. There have been several improvements in the construction of ice houses, but generally they are nothing more than deep cellars, sometimes furnished with a drain, and covered either with thatch or otherwise. On the best means of preserving ice, see the article FREEZING. Dr. Mease considers the ice house at Gloucester-Point Tavern, in the neighbourhood of Philadelphia, as constructed in the best and most economical manner, and therefore recommends it as a pattern. A description of it may be seen in his edition of the Domestic Encyclopædia.

IMPRESSIONS from leaves, how taken. Take green leaves of trees or flowers, and lay them between the leaves of a book till they are dry. Then mix up some lamp-black with drying oil, and make a small dabber of some cotton wrapped up in a piece of soft leather. Put your colour upon a tile, and take some on your dabber. Laying the dried leaf flat upon a table, dab it very gently with the oil colour, till the veins of the leaf are covered; but you must be careful not to dab it so hard as to force the colour between the veins. Moisten a piece of paper, or rather have a piece laying between several sheets of moistened paper for several hours, and lay this over the leaf which has been blackened. Press it gently down, and then subject it to the action of a press, or lay a heavy weight on it, and press it down very hard. By this means you obtain a very beautiful impression of the leaf and all the veins; even the minutest will be represented in a more perfect manner than they could be drawn with the greatest care. These impressions may also be coloured in the same manner as prints.

IMPRESSIONS from insects, how taken.

The following mode of taking an impression from butter-flies, may be used for other insects.

Having taken a butterfly, kill it without spoiling its wings, which contrive to spread out as regularly as possible in a flying position; then, with a small brush or pencil, take a piece of white paper: wash part of it with gum water, a little thicker than ordinary, so that it may easily dry; afterwards, laying your butterfly on the paper, cut off the body close to the wings, and throwing it away, lay the paper on a smooth board, with the fly upwards; and laying another paper over that, put the whole preparation into a screw press, and screw it down very hard. The bill, legs, and feet, must be drawn and coloured from Nature. When it is finished and adjusted to your mind, lay a sheet of paper upon it, and upon that a heavy weight to press it; which must remain till the whole is quite dry.

INDIAN YELLOW. See Colour-Making.

INDIAN RUBBER, gum elastic, or caoutchouc.

This singular vegetable substance was first brought to Europe from South America, about the beginning of the last century. But nothing was known concerning its Natural history, till, in 1756, a memoir was presented to the French Academy by Condamine, in which it is stated, that there grows in the province of Esmeraldas, in Brasil, a tree, called by the natives Hhevé, from the bark of which there flows, on its being wounded, a milky juice, which by exposure to the air, is converted into caoutchouc. M. Freneau discovered the same tree in Cayenne, and transmitted an account of it to the Academy fifteen years after the first notice of it by Condamine Later researches have proved that there are at least two trees natives of South America, from which caoutchouc is obtained, namely, the *Hævea caoutchouc* and *Jatropha elastica*, and it is not improbable that it is yielded by other species of these genera. The American caoutchouc, is generally brought to Europe in the form of globular narrow necked bottles like receivers, about an eighth of an inch thick, and capable of holding from half a pint to a quart or more. In its native country it is fabricated by the inhabitants into vessels for containing water and other liquids; and on account of its ready inflammability is used in Cayenne, as the chief material for torches.

A substance possessing all the properties of the American caoutchonc, has also lately been procured by Mr. Howison, surgeon in Prince of Wales's Island, in the East Indies, from the juice of a climbing plant, the *Urceola elastica*, a native of that small island, and of the coast of Sumatra. The thickest and oldest stems of the urceola yield by far the largest proportion of caoutchouc. If one of these is cut into, a white juice ouzes out, of the consistence of cream, and slightly pungent to the taste. When exposed for a time to the action of the air, or more expeditiously by the addition of a few drops of any acid, a decomposition takes place; the uniform thick cream-like juice, separates into a thin, whitish liquor, resembling whey, and the caoutchouc concretes into a clot or curd, covered superficially with a thin coating of a butyraceous matter. If the juice as soon as collected, is carefully excluded from the air, it may be preserved for some weeks without any material change, but at length the caoutchouc separates from the watery part in the same manner, though not so perfectly as it does by free exposure to the air. The proportion of caoutchouc contained in the juice of the oldest stems is nearly equal to two-thirds of its weight; the juice from the younger trees is more fluid, and contains a considerably smaller proportion of this substance.

Dr. Barton has discovered a plant, indigenous to our soil, which affords a juice which, when inspisated, forms caoutchouc.

According to the experiments of Mr. Howison, cloth of all kinds may be made impenetrable to water by impregnating it with the fresh juice of the Urceola; and the pieces thus prepared, are expeditiously and most effectually joined together by moistening the edges with either the entire juice, or even the more watery part, and then bringing them in contact with each other. Boots, gloves, &c. made of this impervious cloth, are preferable even to those formed of pure caoutchouc, as they are more durable and retain their shape better. If a sufficient quantity of this juice could be obtained, the important purposes to which it might be applied are almost innumerable.

The colour of fresh caoutchouc is yellowish white, but by exposure to the air, it becomes of a smoke-grey: American caoutchouc in the state in which it is brought to Europe, being formed of a multitude of extremely thin layers, each of which is exposed to the air for some time, in order to dry before the next is laid on, is of a yellowish smoke-grey colour throughout; but masses of East-Indian csoutchouc being formed more expeditiously, are dark-coloured only on the outside: when cut into they are of a very light brown, which, however, soon deepens by the action of the air. Caoutchouc is perfectly tasteless, and has little or no smell, except when it is warmed, it then gives out a faint peculiar odour. The elasticity of this substance is very remarkable, and indeed, is one of its most characteristic properties. Slips of caoutchouc, when softened by immersion for a few minutes in boiling water, may be drawn out to seven or eight times their original length, and will afterwards resume very nearly their original dimensions. During its extension a considerable quantity of caloric is given out, which is very perceivable when the piece is held between the lips; and when it is allowed to contract, a decrease of temperature will immediately take place. By successive extensions and contractions in the open air, and especially in cold water, its

elasticity is much impaired, and it refuses to return to its former dimensions; but when in this state it is put into hot water, it imbibes again the heat which it had lost, and by degrees resumes its original size. At the temperature of about 40°, caoutchouc begins to grow rigid, its colour becomes much lighter, and it is nearly opake; as the cold increases it becomes more stiff, and harder, and in all probability, by a pretty powerful freezing mixture, would be made brittle. These changes however, depend merely on temperature, for a piece of hard frozen caoutchouc perfectly recovers its elasticity by being warmed. The fresh cut surfaces of this substance will unite together by simple contact, and by a proper degree of pressure, may be brought so compleatly in union as to be no more liable to separate in this part than in any other. Its specific gravity, according to Brisson, is 0.933 It undergoes no alteration by the action of the air at the common temperature. When boiled for a long time in water, it communicates to this fluid a peculiar smell and flavour, and is so far softened by it that two pieces thus treated and afterwards strongly pressed together, will form a permanent adhesion to each other.

Caoutchouc is soluble with ease at a boiling heat in the expressed vegetable oils, in wax, butter, and animal oil, forming viscid unelastic compounds.

Rectified oil of turpentine at the common temperature acts without difficulty on caoutchouc, first rendering it transparent and enlarging its bulk considerably, and in the course of two or three days effecting a complete solution. The liquor is of the consistence of drying oil, and when spread thin upon wood it forms a varnish, which however is a long time in becoming dry. When mixed with wax and boiled linseed oil, it composes an elastic varnish, which is used in coating balloons.

The only menstrua for this substance from which it can be again separated unaltered are, ether, petroleum, and cajeput-oil.

The solubility of caoutchouc in ether was first discovered by Macquer, a circumstance which, from its frequent failure in the hands of other chemists, was very generally called in question till Cavallo cleared up the difficulty, by showing the necessity of employing *washed* ether for this purpose. If fresh made sulphuric ether is shaken in a vial with an equal quantity of pure water, the small portion of acid which it generally contains is dissolved out by the water, and the ether combines with about a tenth of its weight of this latter fluid. The washed ether is readily separated from the residual water by decantation on account of its superior lightness, and is now capable of effecting a compleat and speedy solution of caoutchouc. The solution is of a light brown colour, and when saturated is considerably viscid. A drop of it let fall into a cup of water immediately extends itself over the whole surface, and the ether being partly absorbed by the water and partly evaporated, the water is found covered with an extremely thin film of caoutchouc, possessing its elasticity and all its other characteristic properties. A similar effect takes place when cloth of any kind is soaked in the solution, or any hard surface is smeared over with it; on exposure to the air the ether is rapidly evaporated, and the caoutchouc which it was combined with is left behind. The affinity of this solution for caoutchouc is very great: if the edges of two pieces of caoutchouc are dipped in it and immediately brought in close contact with each other, as soon as the ether is evaporated they will be found to be perfectly united.

There are two circumstances which must always prevent the extensive use of the etheric solution of caoutchouc, admirably qualified as it is in other respects for many useful purposes; these are, first, its expensiveness, and secondly, the extraordinary rapidity with which the ether evaporates, thus rendering it impossible to lay an even coating of this varnish on any surface, and clogging up the brushes by which it is applied. In order to form tubes or catheters of this substance, the best method is to cut a bottle of caoutchouc into a long single slip, and soak it for half an hour or an hour in ether: by this means it will become soft and tenacious, and if wound dexterously in a spiral form on a mould, bringing the edges in contact with each other at every turn, and giving the whole a moderate and equal pressure by binding it with a tape wound in the same direction as the caoutchouc, a very effectual union will be produced. After a day or two let the tape be taken off, and the cylinder of caoutchouc may be rendered still more perfect by pouring a little of the etheric solution into a glass tube closed at one end, the diameter of which is a little larger than that of the cylinder of caoutchouc; which being introduced into the tube will force the solution to the top of the vessel. Let the whole of the apparatus be then placed in boiling water, the ether will be evaporated, and a smooth and uniform coating of newly deposited caoutchouc will remain upon the cylinder.

Petroleum when rectified by gentle distillation affords a colourless liquid not to be distinguished from the purest naphtha; and this, according to Fabroni, has the property of dissolving one-seventieth of its weight of caoutchouc, and of depositing it again unaltered, by spontaneous evaporation. It does not appear however that this menstruum has been much employed.

The solubility of caoutchouc in cajeput oil was first noticed by Dr. Roxburgh. This is an essential oil procured in India from the leaves of the *Melaleuca Leucadendron*, and promises to be the most useful menstruum of this substance that has hitherto been discovered. The solution is thick and very glutinous. When alcohol is added, this latter unites with the essential oil, and leaves the caoutchouc floating on the liquor in a soft semifluid state, which on being washed with the same liquor and exposed to the air, became as firm as before it was dissolved, and retained its elastic powers perfectly, while in the intermediate state between semifluid and firm, it could be drawn out into long transparent threads, resembling in the polish of their surface the fibres of the tendons of animals; when they broke the elasticity was so great that each end instantaneously returned to its respective mass. Through all these stages the least pressure with the finger and thumb united different portions as perfectly as if they had never been separated, and without any clamminess or sticking to the fingers.

Alcohol has no action whatever on caoutchouc.

Although caoutchouc is procured in quantity only from the vegetable juices mentioned in the former part of this article, yet it appears to be contained in several other plants. It is contained in the milky juices of the Indian fig, *(Ficus Indica,)* and of the bread-fruit tree *(Arto. carpus incisa)*; the berries of the misletoe, and probably all the vegetable barks that yield bird-lime, abound with it. The caoutchouc however obtained from these sources differs from that which we have been describing in retaining a greater or less degree of viscidity, and perhaps in other respects, for no accurate comparative experiments have yet been made to decide this point. An investigation into the properties and composition of the birdlime from misletoe and holly-bark would in all probability lead to very interesting results.

The uses to which caoutchouc has hitherto been applied are the following. It is employed very extensively for rubbing out black-lead pencil marks from paper, hence its usual name of Indian rubber: it is of value to the chemist as a material for flexible tubes to gazometers and other apparatus: the surgeon is indebted to it for flexible catheters and syringes; and finally it enters as an essential ingredient into the composition of the best varnish for balloons. See VARNISH.

INDIGO, or ANIL. This most valuable pigment, which forms so important a part of West and East Indian commerce, is usually brought over in square or oblong cakes of an intense blue colour, almost black in the mass, brittle and friable, light when of a good quality, and of a very peculiar and disagreeable smell.

Indigo is usually reckoned by chemists as a kind of fecula, but of a very peculiar nature, not exactly resembling any other known substance. It is prepared by fermentation of the leaves of the indigo-plant, of which the method, in a short way, is as follows.

There are three principal varieties of the indigo-plant known and used in the West Indies, in Carolina, and the rest of the American continent, from each of which much indigo is obtained: one variety, which is the smallest, is the *Indigofera Tinctoria*, Linn. (called by the French *Indigo-franc*,) which is a delicate plant, rather difficult of cultivation, but which yields indigo in abundance and with ease: a second variety is the *Indigofera Argentea*, Linn. *(Indigo bâtard,)* which is hardy and easily cultivated, and gives a very fine indigo: and a third variety is the *Indigofera Disperma*, Linn. *(Indigo Guatimala,)* which much resembles the last mentioned.

The seed of the plant is sown in about March or April, at Saint Domingo, and the plant comes into flower about three months afterwards, at which time it is in full maturity and is then cut. If it is gathered before flowering, the indigo which it yields is of a finer colour, but much less in quantity.

The chief apparatus of an indigo-house consists of three wooden vats, of different sizes, and arranged on different levels, so that the contents of the first may flow into the second, and of the second into the third. The first is the steeping vat, in which the plant ferments with water; the second is a vat in which the thick fermented mass is beaten violently by machinery; and the third is that in which the indigo settles when fully formed.

The plant being cut, is first laid into the steeping vat so as to fill it entirely but without pressing, and is covered about three inches with water. A frame

of heavy wooden bars is then laid on the vat to keep the plant down when working. Fermentation soon begins in these hot climates, and the whole contents of the vat swell and foam prodigiously like a wine vat in full action, and with disengagement of large bubbles of gas, which, as they burst, appear of a lively green, and tinge the whole vat of the same colour. When this process is at the highest the fermenting mass is also covered with a brilliant *copper-coloured* scum, which passes into violet towards the end, but the pulp and liquor beneath remain green.

The gas given off during the process is inflammable and readily takes fire by applying a lighted candle, and the heaving of the scum is so powerful as often to lift up the heavy wooden frame above mentioned.

The fermentation is known to be carried on long enough by taking samples of the fermenting mass at different times, which when perfect appears as a liquor holding suspended a distinct green pulp, that by a little agitation speedily and completely separates and falls to the bottom of the cup, leaving a clear supernatant gold coloured liquor. Much practical skill is required to seize the exact point when to stop the fermentation, which requires in general from twelve to sixteen hours.

The whole turbid green liquor is then let out of the fermenting or steeping vat and passes into another vessel where it is violently beaten either by the repeated fall of buckets, or by a more complicated mechanical contrivance This has the effect of checking the further fermentation, of preventing putridity, and especially of promoting in a remarkable degree the separation of the *grain* as it is called, or the dark-coloured granular pulp which is the indigo. The whole liquor and pulp during the process change from green to deep blue by the agitation. It is also the custom in many places to add lime-water to the pulp at this time, which is thought to hasten the graining. A large quantity of air-bubbles is also expelled by the beating.

When the grain separates readily and completely by a little rest from the liquor that holds it suspended, the beating is stopped, and the grain slowly subsides. The supernatant liquor is then drawn off by cocks and suffered to run to waste, carefully avoiding to mix it with any brook or drinking pond, which it would poison and render dangerous for animals to use. The thick dark-blue pulp is then let off into the lowest vat, out of which it is laded into common sacks, which when full are hung up that the water may drain off, the indigo itself being too thick to pass through. The indigo is then transferred to small wooden boxes where it is further dried by alternate exposure to sun and shade, and as it becomes solid is cut into square cakes. It is not yet perfect however, for if exported in this state it would mould and spoil, so that a second fermentation is necessary. For this, the cakes are heaped in a cask, and simply suffered to remain for about three weeks. During this time it undergoes a kind of fermentation, heats, sweats at the surface, gives out a disagreeable smell, and is covered with a fine white meal. It is then taken out and dried in the shade for five or six days when it is quite complete.

This, with some slight variations in different plantations, is the general way of preparing indigo, which therefore may be defined to be a fecula or pulverulent pulp separated from the fibre and juices of the entire plant by fermentation, and materially changed by the process, and doubtless by exposure to the atmosphere, so as to pass from green to a deep blue, and from a soluble to an insoluble state.

Indigo is generally packed in chests of about two hundred pounds weight each. The very fine kind that comes from Guatimala is usually wrapped up in goats' skins.

As indigo is an important article in commerce and the arts, it may not be improper to describe some of its prominent characters.

Very singular chemical properties have been discovered in indigo by different experimenters, among whom may be particularly mentioned Bergman, Haussman, and Bancroft. The most singular circumstance concerning indigo, is the insolubility of the blue colouring part in every *simple* menstruum hitherto known (except the sulphuric acid) without such an alteration as entirely destroys the colour for which it is so much valued.

Water boiled long upon indigo (the finest and purest kind being always supposed, as the ordinary sorts are largely adulterated) dissolves about a ninth according to Bergman, or a twelfth according to Quatremere, of the weight. The solution is of a reddish brown colour, and contains what may be called the extractive part, but the colouring portion remains absolutely unaltered, and somewhat of a brighter hue. The watery solution is astringent and mucilaginous.

Alcohol dissolves a still smaller portion than water, and the colouring part remains equally untouched. Ether has

nearly the same effect. Neither the fixed nor the volatile oils have any effect on indigo.

The sulphuric acid is the only single agent that dissolves indigo without destroying its colour; and its application as a dye, in which state it is called *Saxon blue*, has been mentioned under the article DYEING.

The acid should be tolerably concentrated to dissolve the indigo, and it may be used quite concentrated without detriment, at least in small quantities. A moderate heat much assists its action, but if too high, the indigo becomes partially burnt or charred, sulphuric acid gas is given out, and all the portion thus altered remains insoluble and is spoiled. The following recipe for the sulphat of indigo, or Saxon blue, is given by Mr. Woulfe. Mix one ounce of the best powdered indigo with four ounces of oil of vitriol, in a glass matrass, and digest it for one hour in the heat of boiling water, shaking the mixture several times, then add twelve ounces of water to it, stir the whole well, and when cold filter it. This produces a very rich deep blue colour, of a much brighter hue than any of the other solutions of this pigment, but not a fast colour upon animal or vegetable fibres. The colouring power is very great, a few drops of this solution giving a very sensible blueness to a considerable bulk of water.

The nitric acid acts upon indigo with great vehemence, and in a very singular manner. If on a drachm or two of finely powdered indigo be poured about an ounce of fuming nitrous acid, in a short time the mixture heats violently, sends forth a copious flow of nitrous gas, with a stream of sparks, and the whole ends with bursting into flame. When diluted, the acid acts much more mildly, but always with the entire destruction of the blue colour, and in its stead produces a yellow astringent liquor, which is pretty fast upon cotton or cloth dipped in it. This solution however is useless in manufacture. Mr. Haussman has examined with some minuteness the action of nitric acid on indigo. On adding at intervals four ounces of powdered indigo to 16 ounces of common aquafortis heated a little, a great swelling and disengagement of nitrous gas took place, and a coagulum was left, which, when washed with cold water, formed a brown, viscous, and very brittle mass, in appearance like a gum-resin, dissolving in alcohol with ease, but not easily in water, except in a large dose, and hot. The acid liquor in which the coagulum was formed, when evaporated and cooled, let fall more of the same bitter resinous matter, after which it deposited a large quantity of crystals resembling oxalic acid in appearance, but bitter to the taste, and totally differing from it in chemical properties. The nature of these crystals is not well known. An anonymous writer in Nicholson's Journal, on repeating the above experiments, and using a very large quantity of acid, by repeated distillations nearly destroyed the resinous matter, and obtained in the receiver a clear yellow liquor, strongly smelling of bitter almonds, which suggested the idea of its being prussic acid; however after adding alkali to it and sulphat of iron, no blue precipitate was produced.

The oxymuriatic acid acts but feebly on indigo in decomposing or disorganizing it, but destroys the blue colour totally and speedily. Hence the sulphat of indigo has ingeniously been applied as a measure of the intensity of the bleaching power of the oxymuriatic acid.

None of the other acids exert any apparent action on the colouring matter of indigo.

None of the alkalies, nor alkaline earths, either mild or carbonated, when used alone, have any action whatever on indigo in its blue or perfect state. But to effect a solution of it, in alkalies, it is necessary to use some addition, which appears first to change the indigo, and bring it back to a state resembling the recent pulp during the process of manufacture. This at least is made probable by the change of colour that precedes the solution in alkalies, and appears an essential circumstance, and this change is from blue to green of various shades, with a brilliant pellicle on the surface, of the colour and gloss of reguline copper, or rather brighter. This same change, but in a reverse order, takes place in the fermentation of the plant, and process of manufacture; that is, the colour is at first green, with a copper-coloured pellicle, and finally blue.

Indigo not only requires to be changed from the blue to the green state, before it will dissolve in alkalies, but when the solution is made, it only remains dissolved, as long as it continues green, or greenish yellow; for when by any means it resumes its blue state, it immediately becomes insoluble, and separates from the alkaline liquor in form of a dark blue mud, or sediment. Exposure to the atmosphere regenerates blue indigo in a remarkable manner, so that if a drop of the solution be poured on paper, the surface turns from green and yellow to blue in a very few seconds, which last colour

may be again removed (but irrecoverably so) by the oxymuriatic acid. From these and other circumstances, Dr. Bancroft infers, that the cause of the change arises from the different degree of oxygenation, the green being in the lowest state of oxygenation, and the blue in the highest. The substances that form proper additions to enable alkalies to dissolve indigo are very numerous, and very discordant in their nature, for not only have the metallic sub-oxyds this power, (as might be expected) but even almost every soluble vegetable matter has the same, such as sugar, raisins, bran, &c. &c. A very simple, and efficacious way of dissolving indigo, is by means of the oxyd of tin; for which, let some well saturated muriat of tin be super-saturated with potash, so that the precipitate at first formed, may be redissolved, and the solution converted into an alkaline one, after which, indigo will dissolve in it readily, and assume almost instantly a deep green colour.

The particular methods of preparing these solutions in the indigo vats, for the use of the dyer, are described sufficiently under the article DYEING.

The analysis of indigo by fire only, affords but little insight into its composition. When distilled *per se*, some ammonia and a peculiar oil rise, and if afterwards burnt away, nothing remains but a very small portion of a very light brown powder or ash. This is a tolerable test of its goodness, as there is hardly any vegetable that leaves so small a portion of ashes.

INFUSION, is the maceration of any substance in water, or any other liquid, hot or cold, with a view of extracting its soluble parts. The liquid thus impregnated is called *an Infusion.*

INGOT.—An ingot is a small bar of metal made of a particular form and size, (generally a very long parallellopepid) by casting it in hollowed iron or brass plates, called *ingot moulds.* It is chiefly to the small bars of gold and silver that the term ingot is applied.

INK. *Common writing.*—The preparation of common writing ink, is a subject of great importance in technical chemistry. A good ink is of a proper consistence to flow freely from the pen, of a full deep black, so permanent as to remain for a number of years without materially fading or becoming illegible, dries very soon after writing with it, and does not considerably corrode, or soften the pen. The basis of all the common writing inks is the fine black, or dark blue precipitate, formed by the addition of vegetable astringents, and particularly of the soluble part of the gall-nut, to a solution of iron, generally the sulphat. But as this, if diffused in water alone, would subside in a short time, and leave the supernatant liquor nearly without colour, the precipitate is kept suspended, by thickening the water with gum arabic, or any other gum mucilage, which also gives the ink the due consistence, and enables it to trace a fine stroke on the paper without running. These materials therefore, that is, gall-nuts, green vitriol, (sulphat of iron) gum arabic, and water, are all that are necessary for the composition of ink, and if they are of good quality, and properly proportioned to each other, every other addition usually made, adds very little to its perfection.

It is not well ascertained how soon the present kind of writing ink came into use. It has certainly been employed for many centuries in most European countries, but the ancient Roman inks were for the most part of a totally different composition, being made of some vegetable carbonaceous matter like lamp-black, diffused in a liquor. The Chinese and many of the other inks used by the Oriental nations, are still of this kind.

On the subject of the common writing ink, Dr Lewis has given so full and so accurate an investigation, and his experiments are so simple and well devised, that little else can be added to the subject in a technical point of view.

Dr. Lewis first endeavoured to ascertain the best proportion between the galls and the sulphat of iron, to render the ink permanent; for it is to be observed that with almost any proportions, if the entire quantity be sufficient, the ink will be fine and black at first, but many of these inks if kept for some time, especially exposed to light and air, will grow brown and fade, and the letters made with it will become nearly illegible.

By trying different proportions of galls and sulphat of iron, it was found, that when about in equal quantities (the galls being powdered and boiled fully to extract their soluble parts) they appeared to be mutually saturated, so that the mixed liquors would receive no additional blackness from a further dose of one or the other. This however was only a rough approximation to accuracy, for the same effect was produced when either substance was also in a small degree superior in quantity to the other. But Dr. Lewis found that an ink with equal parts of the two, though very black at first, changed to a yellowish brown upon exposure to the sun and air only for a few

days. This was again blackened by washing with fresh gall-infusion, and hence it appears a fair inference that the galls are in some degree a perishable substance, so that to ensure durability, a much greater proportion must enter into the ink than is required for mere saturation in the first instance. Thus it was found that two parts of galls and one of vitriol, make a much more durable ink than with equal parts, and three of galls with one of vitriol was still more durable. When the galls were encreased beyond this point the colour was indeed quite permanent, but it was not of so full a black.

The proportion of water or other liquid to the solid ingredients will admit of great variation. One part of vitriol three of galls, and fifty parts of water, gave an ink black enough for common use, but the finest and blackest was made when only ten of water were employed; nor was any deficiency in the gallic acid observed after fifteen years, though the water was scarcely more than sufficient to cover the galls, and therefore could hardly be supposed capable of extracting all the soluble part of them, and though the vitriol, from its greater solubility, would probably be dissolved entirely, and thus be in greater proportion than usual. Other liquors besides water were tried Of these white wine and vinegar appeared to answer somewhat better, but any considerable proportion of spirit of wine, or brandy, obviously did harm, owing to the insolubility of the sulphat of iron (as of all the other sulphats) in alcohol, and therefore its diminished solubility in any liquor is in proportion to the alcohol it contains. A decoction of logwood used instead of water, sensibly improved the beauty of the colour.

Instead of galls other astringents were employed, such as sloes, oak-bark, tormentil root, &c. but though they all gave a good blue-black with the salt of iron, none of them was equal to the gall-nut in this respect.

Other salts of iron were also substituted to the sulphat. The muriat and nitrat of iron nearly equalled the sulphat in colour, but proved too corrosive to the paper, and as they were in no respect preferable to the sulphat, there is no reason for abandoning it.

Imagining that there must be some excess of sulphuric acid in common ink, to which the fading might be imputed, Dr. L. tried to neutralize it by lime and alkalies, but with manifest injury, the colour being rendered thereby extremely fugitive. Another ingenious idea for avoiding the supposed excess of acid, was to separate the black atramentous precipitate, wash it, and again diffuse it with water thickened with gum. This did indeed make a very good ink, but with the capital defect of not remaining so long suspended in the liquor, and especially of not fixing itself to the paper like common ink, but rather only slightly adhering like a weak gum varnish, and was readily washed off by water. Hence it appears that the acid of the salt of iron acts as a kind of mordant or intermede, between the atramentous precipitate and the paper, and causes a degree of chemical union between them: a real advantage which this species of ink possesses over all the lamp-black or China inks, which indeed are rather black varnishes.

With regard to the gummy ingredient, the effect of which is chiefly mechanical, it was found that any other gum-mucilage would answer as well, but not glue, isinglass, nor animal jelly of any kind. Besides as these latter putrify by keeping, this alone would be a strong objection.

Sugar is sometimes added to ink. It makes it flow somewhat easier from the pen, and gives it when dry a gloss which is admired by some. It has this quality however of making it very slow in drying, which in most cases is an inconvenience.

On account of the great improvement to the black atramentous dye produced by adding sulphat of copper; some have recommended this addition to common ink, which is composed of the same materials; but it does not appear that the same advantage is here obtained, and Dr. Lewis thinks it an useless addition.

From the above observations Dr. Lewis gives the following receipt for the composition of ink: Put into a stone or glass bottle, or any other vessel, three ounces of finely powdered galls, one ounce of green vitriol, one ounce of log-wood finely rasped or bruised, one ounce of gum arabic, and a quart of soft water. Shake the bottle well, and let the ingredients stand in a moderately warm place for a week or ten days, shaking it frequently in the day. It is then fit for use, but a little before it is put into the ink-stand, it is better to shake the bottle that the colour may be more uniformly diffused.

To prevent the ink from moulding, Hoffman recommends half a dozen cloves to be bruised with the gum arabic and put into the bottle. This appears an useful addition. Instead of water alone, where a very fine ink is wanted, white wine or vinegar and water may be used.

If the ink be wanted for use in a very

short time, the galls and logwood may be boiled for half an hour in the water, adding a little more to supply the waste, and the decoction, while hot, strained off through a cloth, and the gum arabic and cloves, and the sulphat of iron, both in fine powder, added to the decoction when in the bottle and shaken. The ink will then be fit for use almost immediately after the latter ingredients are dissolved. It will be improved by adding to the bottle some pieces of gall-nut coarsely bruised.

Ink kept in a close bottle is always rather pale, but it blackens by exposure to air in a few hours, and probably in this way the colour is somewhat more durable than if it were brought by previous exposure to its full colour at once.

It has been mentioned that sugar renders ink slow in drying. Advantage is ingeniously taken of this property in enabling it to give one, and sometimes two impressions on soft paper when strongly pressed. In this simple way letters are copied in merchants counting-houses, and offices of business. A little sugar is mixed with the ink, the written sheet is laid on the copying press, a blank sheet of porous and damped paper is put over it, and by the pressure of the machine a perfect fac-simile of the writing is struck off, sufficiently legible for all purposes.

This ingenious method saves a vast quantity of labour usually bestowed in copying letters, and besides prevents all possibility of mistake.

As common writing ink is susceptible of being effaced by oxygenated muriatic acid, and as the knowledge of this fact may be abused to very fraudulent purposes, chymists have judged it an object of importance to try, whether a writing ink might not be prepared, which should entirely resist the action of that acid. Pitet, with this view, added to the ink commonly in use, a portion of indigo. But this addition is of no service if the ink be not carefully shaken every time it is employed. Westrumb recommends the following composition of ink, as absolutely indestructible. Boil one ounce of fernambuco, and three ounces of nut galls, in forty-six ounces of water, till they shall be reduced to thirty-two ounces in all. Pour this decoction, while it is yet hot, upon half an ounce of sulphate of iron, or martial vitriol, one quarter of an ounce of gum arabic, and one quarter of an ounce of white sugar. After these substances are dissolved, add to the solution one ounce and a quarter of indigo, finely pulverized, with three quarters of an ounce of lampblack, very pure, or of smoke black, previously diluted in one ounce of the best brandy. M. Bosse gives a receipt, which is still more simple. He directs to boil one ounce of fernambuca with twelve ounces of water, and half an ounce of alum; to continue the ebullition till the liquid mixture shall have been reduced to eight ounces; then to add an ounce of oxyd of manganese, which you have reduced by decantation to extreme fineness, and, in mixture with it, half an ounce of gum arabic.

Sometimes the ink of very old writings is so much faded by time as to be illegible. Dr. Blagden in his experiments on this subject found, that in most of these the colour might be restored, or rather a new body of colour given, by pencilling them over first with a solution of prussiat of potash, and then with a dilute acid either sulphuric or muriatic; or else vice-versa, first with the acid and then with the prussiat. The acid dissolves the oxyd of iron of the faded ink, and the prussiat precipitates it again of a blue, which restores the legibility of the writing. If this be done neatly and blotting paper laid over the letters as fast as they become visible, their form will be retained very distinctly. Pencilling over the letters with an infusion of galls also restores the blackness to a certain degree, but not so speedily nor so completely.

The blackness of common ink is almost instantly and irrevocably destroyed by the oxymuriatic acid, and hence any writing may be effaced by this method completely. To prevent this mischief, which might often be a serious one, several additions have been proposed to common ink, of which by far the best is lamp-black or charcoal, in impalpable powder, on which the acid has no effect. The lamp-black should be of the least oily kind, as it does not readily mix with the ink, and some pains must be taken to incorporate them. On this account perhaps common charcoal is preferable. About a quarter of the weight of the vitriol used will be amply sufficient. This will not fade by age.

Indelible Ink.—Receipt. Lunar caustic, one ounce: weak solution of galls, two ounces. The cloth to be first wetted with a solution of one ounce of salt of tartar dissolved in one ounce of water, and must be quite dry before using the ink.

Another.—Dissolve 4 drachms of lunar caustic in 4 ounces of rain or river water. To the clear solution add 60 drops of an infusion of 2 drachms of powdered galls in a gill of boiling water.

The cloth is to be previously wetted with a solution of 1 ounce of pearl ash in

4 ounces of water, and suffered to dry thoroughly.

Ink, China or Indian.—The well known and much admired Indian or China ink, is brought over in small oblong cakes, which readily become diffused in water by rubbing, and the blackness remains suspended in it for a considerable time, owing to the extreme sublety of division of the substance that gives the colour, and the intimacy with which it is united to the mucilaginous matter that keeps it suspended.

Indian ink does however deposit the whole of its colour by standing, when it is diffused in a considerable quantity of water. Dr. Lewis on examining this substance found that the ink consisted of a black sediment totally insoluble in water, which appeared to be of the nature of the finest lamp-black, and of another substance soluble in water, and which putrefied by keeping; and when evaporated left a tenacious jelly exactly like glue or isinglass. It appears probable therefore that it consists of nothing more than these two ingredients, and probably may be imitated with perfect accuracy by using a very fine jelly, like isinglass or size, and the finest lamp-black, and incorporating them thoroughly. The finest lamp-black known is made from ivory shavings, and thence called *ivory-black*.

Ink, Printers.—This is a very singular composition, partaking much of the nature of an oil varnish, but differing from it in the quality of adhering firmly to moistened paper, and in being to a considerable degree soluble in soap water.

It is, when used by the printers, of the consistence of rather thin jelly, so that it may be smeared over the types readily and thinly, when applied by leather cushions, and it dries very speedily on the paper without running through to the other side, or passing the limits of the letter.

The method of making printer's ink is thus described by Dr. Lewis.

Ten or twelve gallons of nut oil are set over the fire in a large iron pot, and brought to boil. It is then stirred with an iron ladle, and whilst boiling, the inflammable vapour rising from it either takes fire of itself, or is kindled, and suffered to burn in this way for about half an hour, the pot being partially covered so as to regulate the body of the flame, and consequently the heat communicated to the oil. It is frequently stirred during this time, that the whole may be heated equally, otherwise a part would be charred and the rest left imperfect. The flame is then extinguished by entirely covering the pot. The oil by this process has much of its unctuous quality destroyed, and when cold, is of the consistence of soft turpentine, and is then called *varnish*. After this it is made into ink by mixture with the requisite quantity of lamp-black, of which about 2½ ounces are sufficient for 16 ounces of the prepared oil. The oil loses by the boiling about an eighth of its weight, and emits very offensive fumes. Several other additions are made to the oil during the boiling, such as crusts of bread, onions, and sometimes turpentine. These are kept secret by the preparers. The intention of them is more effectually to destroy part of the unctuous quality of the oil, to give it more body, to enable it to adhere better to the wetted paper, and to spread on the types neatly and uniformly.

Besides these additions, others are made by the printers, of which the most important is generally understood to be a little fine indigo in powder, to improve the beauty of the colour.

For further observations on the nature of fixed oils, and the alteration they undergo by heat, see OIL.

Red printers ink is made by adding to the varnish about half its weight of vermillion. A little carmine also improves the colour.

Inks, coloured. Few of these are used except red ink. The preparation of these is very simple, consisting either of decoctions of the different colouring or dyeing materials in water, and thickened with gum arabic, or of coloured metallic oxyds or insoluble powders merely diffused in gum water. The proportion of gum arabic to be used may be the same as for black writing ink. All that applies to the fixed or fugitive nature of the several articles used in *dyeing*, may be applied in general to the use of the same substances as inks.

Red Ink, is usually made by boiling about two ounces of Brazil wood in a pint of water for a quarter of an hour, and adding to the decoction the requisite quantity of gum, and about half as much alum. The alum both heightens the colour and makes it less fugitive. Probably a little madder would make it more durable.

To make Red Ink that will not change its colour—Take four grains of the best carmine, and pour thereon two ounces of caustic ammonia, adding twenty grains of the clearest gum arabic; let them remain until the gum is dissolved. This ink, however it may be something dearer than in the ordinary way of its preparation, is of much finer colour and more durable: for by experience it is known that charac-

ters which have been traced with this ink, have remained perfectly fresh for forty years afterward.

Blue Ink, may be made by diffusing Prussian blue or indigo through strong gum-water.

Yellow Ink, may be made by a solution of gamboge in gum-water.

Most of the common water-colour cakes diffused in water, will make sufficiently good coloured inks for most purposes.

INKS, *Sympathetic or Secret*.

These are all liquids which have scarcely any colour in their common state, and therefore when characters are traced with them on paper they are invisible, or nearly so, at first, but a colour is given to them either by applying some chemical reagent, or by mere heat. A considerable number of these have been invented, some of which may be just enumerated.

The sympathetic ink of cobalt is the best known and the most singular. Any solution of this metal that contains muriatic acid in any form becomes green when heated, but returns to a state nearly colourless when cold. This also will appear and vanish alternately by heating or cooling. When the cobalt is pure the colour approaches strongly to blue. See COBALT.

Characters written with lemon-juice are invisible at first, but on strongly heating the paper, the extractive matter of the lemons turns brown, and thus becomes visible.

Sulphuric acid moderately diluted, answers in the same way. On heating the paper the water of the acid flies off, the latter becomes thereby concentrated, and acts on the paper, making it brown.

Of the secret inks formed by the action of reagents, the metallic solutions that are blackened by a liquid sulphuret, or sulphuretted hydrogen gas, are the best known. These metallic solutions are those of lead, silver, bismuth, and mercury.

The acetite of lead is one of the most convenient. Letters written by any of these solutions, are at once blackened and rendered visible, by being wetted with the sulphuretted solution, or more slowly by exposure to the gas. The solutions may be very dilute, as the deepening of colour is very powerful.

A weak solution of gallic acid diluted so as to be colourless. will also be blackened by any salt of iron.

Prussiat of potash will likewise become blue by any solution of iron.

IRON. Iron is a metal, of a blueish grey colour, hard, ductile and malleable; capable of acquiring magnetic polarity, and of being welded; soluble in the muriatic and most other acids; precipitable in the state of Prussian blue by a prussiated alkali, and assuming a deep bluish-black colour, with infusion of gall-nut.

Ores of Iron.

Native Iron. Its colour is light steel-grey, resembling white cast iron or platina; but it is generally covered by a thin superficial crust of brown oxyd. It occurs branched or cellular. Its lustre is moderately shining and metallic. Its fracture is hackly; it gives a bright streak, may be easily cut with a knife, and is perfectly malleable when cold, and in a moderate heat, but at a high temperature it becomes brittle and granular; it is flexible and difficultly frangible. Sp. gr. not exceeding 6.48.

A mass of native iron, reported by the inhabitants of the country to have fallen from the sky, was found by Professor Pallas in Siberia. Between the rivulets Ubei and Sissim, that run into the Jenisei on the eastern side, is a mountain containing a rich mine of magnetic iron ore; on the same side of the mountain where this mine is situated, was found lying loose on the rock the mass of native iron alluded to, weighing 1680 Russ. lbs. This mass is cellular, and the cells are either empty or occupied by a transparent greenish yellow substance, at first taken for fluor spar, but which on subsequent examination greatly resembles the chrysolite.

A still larger mass of native iron was seen and described by Don Rubin de Celis. It is situated in the district of Otumpa, in the Vice-royalty of Peru; its weight is about 15 ton; it is compact externally, and is marked with impressions as if of hands and feet, but much larger, and of claws of birds; internally it is full of cavities. It is almost imbedded in white clay, and the country round it quite flat and destitute of water. Another mass of iron likened in shape to a fallen tree, has also been seen in the same territory.

Native iron, in detached masses, and of a cellular texture, has also been found near Tabor in Bohemia, and in Senegal in Africa.

Native iron has also been found imbedded in brown ironstone, spathose ironstone, and heavy spar, at Kamsdorf in Saxony, and is said to have occurred stalactitical with brown ironstone and quartz, forming a vein in the mountain of Oulle, near Grenoble.

Unmagnetical Iron Pyrites.

Of this there are the five following subspecies.

1. Subsp. Common Pyrites.

Its colour is perfect brass-yellow,

sometimes by tarnishing it is superficially reddish or brownish.

It occurs massive, disseminated, investing, and crystallized. Its primitive crystalline form is the cube, which passes into a number of varieties

When exposed to the blowpipe on charcoal, it emits a strong sulphureous odour, and burns with a bluish flame. It then becomes a brownish globule, attractable by the magnet, and by a further continuance of the heat passes into a blackish slag.

According to the experiments of Mr. Hatchett, the pyrites with smooth cubes, consists of

Sulphur	52.70
Iron	47.30
	100.0

Pyrites with striated cubes contains

Sulphur	52.5
Iron	47.5
	100.0

and dodecahedral pyrites contains

Sulphur	52 15
Iron	47.85
	100.00

The striated cubes and dodecahedrons sometimes contain gold, and hence are named auriferous pyrites.

Common pyrites is in almost every mineral formation, and almost every species of rock. It abounds in granite, and particularly in primitive and transition argillaceous schistus.

It is never wrought as an ore of iron, but is largely employed in the manufacture of green vitriol, and sulphur is often procured from it by sublimation, while the residual red oxyd is valuable as a coarse kind of paint.

Radiated Pyrites.

Its colour is brass-yellow, but paler than common pyrites; its surface is generally tarnished, It occurs in mass, but most usually in particular forms, such as kidney-shaped, tuberous, globular, botryoidal, scaly, stalactitic, &c. Also in minute crystals between the cube and octohedron. When the crystals are very much flattened and united in diverging groups, they form the cock's-comb pyrites. The surface of the crystals is either smooth or drusy, and therefore their external lustre is subject to corresponding variations. The fracture is for the most part divergingly radiated in stars or bundles, with short strait fibres. It sometimes passes into parallel-fibrous, and even into compact. Its fragments are wedge-shaped. It occurs in coarse and large granular distinct concretions, also in thin curved lamellar, and in thin columnar distinct concretions. It is hard, brittle, and very easily frangible. Sp. gr. 4.69 to 4.77.

It is composed according to Hatchett of

Sulphur	53.6	—	54.34
Iron	46.4	—	45.66
	100.		100.

It is rarer than common pyrites, and occurs principally in small masses, and in veins with ores of lead or silver.

Capillary pyrites.

Its colour is bronze yellow, passing into steel-grey. It occurs in delicate capillary crystals aggregated into divergent bundles or promiscuously. In other particulars it agrees with the preceding, of which it is little else than a variety.

It is the least frequently met with of any of the kinds of pyrites. It occurs in veins with silver ores, accompanied by quartz, calcareous and fluor spars, in Saxony and the Hartz.

4. *Subsp.* Cellular pyrites.

Its colour is bronze yellow inclining to greenish and steel-grey. It becomes of a grey colour by tarnishing. It occurs cellular; its fracture is even and flat conchoidal passing into fine-grained uneven. In other respects it resembles common pyrites, into which it occasionally passes. It is the least subject to decomposition of the whole species. It occurs in metallic veins in Saxony.

5. *Subsp.* Liver pyrites.

Its colour is intermediate between pale brass-yellow and steel-grey; its external surface is usually brownish or iridescent. It occurs in mass, disseminated, globular, tuberous, reniform, stalactitic and cellular; also crystallized in six-sided prisms or pyramids. Internally it is usually glimmering, with a metallic lustre. Its fracture is even, passing into fine granular or flat conchoidal. It occurs in distinct concretions. It is met with only in metallic veins and is very subject to decomposition.

Magnetical Pyrites.

Its colour is intermediate between brass-yellow and copper-red, and sometimes inclines to tombac brown: by exposure to the air it acquires a brownish tarnish. It occurs only in mass and disseminated. Internally it is shining or glistening, with a metallic lustre. Its fracture is fine or coarse grained uneven, sometimes passing into imperfect conchoidal. It breaks into indeterminate blunt edged fragments. It affords a few occasional

sparks with steel; is brittle and easily frangible. Sp. gr. 4.518.

It is especially distinguishable from the preceding species in being attracted by the magnet and giving out sulphuretted hydrogen by digestion in muriatic acid. Its component parts, according to Mr. Hatchett, are

Sulphur	36.5
Iron	63.5
	100.

It is said to be found only in beds in primitive mountains, in gneiss, micaceous schistus, primitive greenstone and limestone, where it occurs with common martial pyrites, copper pyrites, arsenical pyrites, galena, blende, magnetic iron-stone, garnet, hornblende, and actynolite. It is met with in Bohemia, Bavaria, and Silesia, also in Norway, and has recently been found by Mr. Greville, near the base of Moel Elion in Caernarvonshire, where it forms a thick vein or more properly a bed, as Jameson conjectures. Besides the above localities, it occurs disseminated in transition greenstone, a little to the south of Pont Aberglaslyn, in Caernarvonshire; and forming a large bed with black calcareous spar in transition slate, not far from Trefriew in the vale of Conway, in the same county. At this last place it is procured in considerable quantity for the sulphur which it yields by sublimation and the red ochre which remains after the separation of the sulphur.

Sp. 4. *Magnetical Iron Stone.*

Of this there are the two following subspecies.

1. *Subsp.* Common Magnetic Iron stone.

Its colour is iron-black, often superficially tarnished. It occurs massive, disseminated and crystallized. The forms of its crystals are,

1. The octohedron.
2. The garnet dodecahedron.
3. A rectangular four-sided prism, terminated four-sided pyramids.

It is not only attractable by the magnet, but itself possesses polarity, hence it takes up iron filings. Before the blowpipe it becomes brown and tinges glass of borax of a dark green colour. It has not been regularly analyzed, but is supposed to be nearly a pure oxyd of iron. When smelted in the large way it is said to yield from 80 to 90 per cent. of metal, but this is manifestly impossible; a more probable estimate is from 60 to 70 per cent. It occurs most frequently in primitive mountains and chiefly in gneiss, micaceous schistus, chlorite slate, and primitive limestone: also in serpentine, and in the floetz-trap formation. When in mass it forms beds and sometimes considerable rock-masses. It is usually accompanied by horn-blende, granular limestone, and garnet; also, though more rarely, by amianth, actynolite, fluorspar, coccolite, sahlite, augite, all the varieties of pyrites, blende, tinstone and galena.

The Mountain Taberg in Swedish Lapland, and Pumachanche in Chili, are said to consist almost entirely of this mineral. It exists in great abundance and purity in Roslagia in Sweden, where it is manufactured into the best bar iron, so much sought after by the English manufacturers of steel. It also occurs in sufficient plenty to be smelted in the islands of Corsica and Elba; Arendahl in Norway; in Saxony, Bohemia, Silesia, and the Hartz in Germany; in many places among the Uralian mountains in Russia; and in Siam in the East Indies.

When pure it affords the best bar iron, but only middling cast iron: it is easily fusible and requires but little flux.

2. *Subsp.* Magnetic iron sand.

Its colour is deep iron black. It occurs in angular and roundish grains from the smallest dimensions to the magnitude of a hazel-nut; also in octohedral crystals. Both the grains and crystals are externally somewhat rough and glimmering. Internally it exhibits a bright-shining metallic lustre. Its fracture is perfectly conchoidal and rarely imperfectly foliated. Its fragments are indeterminate and sharp-edged. It gives a greyish-black powder. It is moderately hard, brittle and easily frangible. Sp. gr. 4.6.

It is powerfully attracted by the magnet, but is scarcely at all acted on by the muriatic or nitric acids.

It seems to belong almost entirely to the floetz-trap formation, and is found imbedded in basalt and wakke, or loose in the beds of rivers. It does not often occur in sufficient abundance to be smelted, yet it is employed for this purpose in the Tyrol, near Naples, and in Virginia, and produces about 60 per cent. of excellent bar iron.

Sp. 5. Specular Iron Ore.

Of this there are the two following subspecies.

Subs. 1. Common Specular Iron ore. *Gemeiner Eisenglanz*, Wern. *Fer speculaire commun*, Broch.

Its usual colour is deep steel-grey, passing sometimes in the crystallized varieties to iron black, and in the massive varieties to brownish red. It is often tarnished externally, and then presents the blue and yellow tints of tempered steel.

It occurs in mass, disseminated and crystallized. The colour of its streak is cherry-red. It is hard, brittle, not very easily frangible. Sp. gr. 4.7. to 5.2.

When pulverized it is slightly magnetic. It is infusible *per se*, before the blowpipe; with borax it gives a dirty yellow slag. According to Kirwan it consists of iron and oxygen in the proportion of from 60 to 80 of the former and from 20 to 30 of the latter.

It occurs in beds and veins in primitive and transition mountains, and is generally accompanied by magnetic iron-stone and compact red iron-stone, iron pyrites and quartz. The greater part of the iron ore of Elba is of this species; it also abounds in Sweden and Norway, in Bohemia, Saxony, Silesia, Switzerland, France, Russia, and Siberia. It affords an excellent malleable iron, but somewhat hard, and also a good but not the very best cast iron.

2. *Subsp.* Micaceous iron ore.

Its colour is iron-black passing into steel-grey; and the thin plates of which it consists when held between the eye and the light appear blood-red. It occurs massive, disseminated, or superficial, or crystallized in thin hexahedral tables, which sometimes intersect one another so as to form cells. The surface of the crystals is smooth and almost specular. Internally it is more or less shining, with a metallic lustre. Its fracture is perfectly foliated; the lamellæ are curved and divisible only in one direction. Its fragments are either indeterminate or in the form of plates. When in mass it occurs in thin and curved lamellar or granular distinct concretions. The thin plates are sometimes faintly translucent. The colour of its streak is cherry red. It is moderately hard, but becomes soft in proportion as it passes into the red scaly iron ore: it is brittle and easily frangible. Sp. gr. 4.5 to 6.0.

It occurs only in primitive mountains, but chiefly abounds in the most recent of these. It lies in beds and veins accompanied by red and brown iron-stone and iron pyrites.

It affords on analysis upwards of 70 *per cent.* of iron. In the great way it is found to melt more easily than the preceding subspecies, provided a sufficient quantity of limestone is added to it by way of flux. The iron that it affords is sometimes cold-short but is well fitted for cast ware.

It is met with in Norway, Sweden, various parts of Germany, Dauphiné in France, Piedmont, and the island of Elba in Italy, the forest of Dartmoor in Devonshire, near Dunkeld in Perthshire, and in Mainland, one of the Shetland islands.

Sp. 6. Red Ironstone.

Of this there are four subspecies.

1. *Subsp.* Red scaly iron ore.

Its proper colour is cherry red, but it also passes into blood-red, brownish-red, steel-grey and iron-black. It occurs sometimes in mass, but more frequently as a superficial covering to other ores of iron. It is glistening, with a semi-metallic lustre. It is composed of friable scaly particles more or less cohering together. It stains the fingers, is unctuous to the touch, and moderately heavy.

When exposed to the blowpipe without addition it blackens but does not melt. It communicates to glass of borax an olive green colour.

Its component parts, according to Mr. W. Henry, are

Iron	66
Oxygen	28.5
Silex	4 25
Alumine	1.25
	100.00

It occurs usually in veins in primitive mountains, also in transition mountains. It is commonly accompanied by the other subspecies of red ironstone and spathose iron. It passes into micaceous iron ore.

It is found at Ulverstone and other places in the North of Lancashire. At Sahl in the Dutchy of Henneberg, it is smelted and produces very good iron.

2. *Subsp.* Red Ochre.

Its colour is blood-red passing into brownish red. It is found in mass, disseminated and superficial. It has little or no lustre. Its fracture is earthy. It stains the fingers; is usually friable and very tender, but in some varieties passes into solid: to the touch it is smooth and somewhat meagre. Sp. gr. 2.95.

It is found accompanying the other subspecies of red iron-stone, but rarely in any considerable quantity. It is smelted in the Irrgange near Platte in Bohemia, is very fusible, and affords excellent malleable iron.

3. *Subsp.* Compact red Iron-stone.

Its colour is intermediate between brownish red and dark steel-grey, it passes sometimes to blood-red. It occurs in mass or disseminated, or in particular shapes, such as globular reniform, specular, cellular, in pseudomorphous pyramidal crystals, or rarely in real cubic crystals, either solitary or in groups. The surface of the true crystals is smooth, of the others rough. The external lustre is subject to several variations: internally it

is rarely more than glimmering, semi-metallic. Its fracture is commonly even, whence it occasionally passes into coarse grained, uneven, and large conchoidal: sometimes also it is found slaty. Its fragments are indeterminate blunt-edged. It exhibits rarely testaceous or prismatic distinct concretions. It is commonly of moderate hardness and easily frangible. It gives a blood-red streak and is apt to stain the fingers. Sp. gr. 3.42 to 3.76.

It acquires a dark tinge before the blowpipe, but is infusible either by itself or with borax, to which however it gives an olive-green colour. Its constituent parts, according to Lampadius, are

Oxyd of iron	65.4
Silex	20.7
Alumine	9.3
Oxyd of manganese	2.7
	98.1

It occurs in beds and veins usually with red hæmatite and red ochre, also with quartz, horn-stone and red jasper. It is met with in various parts of Germany (the crystallized varieties come from Oberhals in Bohemia) in Norway, Siberia, and in considerable quantities in Lancashire. It affords good cast iron, and pretty malleable though somewhat soft bar iron.

4. *Subsp.* Red Hæmatite.

Its colour is intermediate between brownish red and steel-grey, sometimes it passes into blood-red and bluish-grey. It occurs in mass, also of particular shapes, such as reniform, botryoidal, stalactical and globular. Its external lustre is casual; internally, it is usually glistening, with a semi-metallic lustre. Its fracture is strait fibrous, either delicate or coarse; parallel, radiating or in bundles Its fragments are wedgeshaped, sometimes in the coarse fibrous variety, splintery. It occurs almost always in distinct concretions either large or small granular or curved lamellar. It gives a blood-red streak; is hard, brittle, and generally stains the fingers. Sp. gr. 4.84 to 6.0.

It has not yet been analysed with any accuracy, but from the results in the large way it contains about 60 per cent. of iron, and is the richest of the whole species. It occurs in the same situations with the preceding subspecies in veins, beds and rock masses in primitive transition and floetz mountains. It affords excellent iron both cast and malleable; most of the plate-iron and iron wire of England is made from it. When ground to a fine powder it is largely employed as a polishing material by most workers in metal.

It is particularly abundant in Lancashire, in the Forest of Dean in Gloucestershire, in Devonshire and in Saxony, but is scarcely at all to be met with in Norway, Sweden, Poland, Hungary and Russia.

Sp. 7. Brown Ironstone.

This like the former is to be divided into four subspecies.

1. *Subsp.* Brown scaly iron ore.

Its colour is intermediate between steel-grey and clove-brown. It occurs seldom in mass, disseminated or globular, but more frequently superficial and frothy, sometimes also irregularly dendritical. It has a considerable metallic lustre. Its fracture is small lamellar passing into compact. It is very soft and almost friable; stains the fingers, is somewhat unctuous to the touch; is light, so as sometimes to float on water.

It blackens before the blowpipe but does not melt, it tinges glass of borax of a yellowish-green colour. It has not been analysed.

It occurs lining cavities in brown hæmatite.

2. *Subsp.* Brown Iron ochre.

Its colour is light yellowish brown, inclining to ochre-yellow and clove-brown. It occurs in mass and disseminated. It is destitute of lustre; has an earthy fracture; its fragments are indeterminate blunt edged. It is tender, passing into friable; soils the fingers, and is heavy.

It has not been analysed. It becomes black by ignition, whence it is distinguished from yellow earth which burns red. It accompanies brown hæmatite.

3. *Subsp.* Compact brown Ironstone.

Its colour is clove-brown. It occurs massive and disseminated, also of particular shapes, such as cylindrical, stalactitic, reniform, cellular, with pyramidal impressions, and rarely in pseudomorphous cubes, rhombs, and lenses. It also forms the substance of several petrefactions, especially of madreporites, corralites and fungites. Internally it is dull or faintly glimmering. Its fracture is usually even, sometimes large and flat conchoidal, also fine grained, uneven, and earthy. Its fragments are indeterminate blunt edged. Its streak is yellowish-brown passing into ochre-yellow. It is moderately hard, and easily frangible. Sp. gr. 3.5 to 3.75.

Before the blowpipe it becomes black and magnetic. It accompanies brown hæmatite.

4. *Subsp.* Brown Hæmatite.

The colour of the recent fracture is clove brown passing into steel-grey, blackish brown and brownish-black, or rarely into yellowish brown and ochre yellow. The external surface tarnishes to black, bluish black, tombac brown,

bronze and gold-yellow: it also often presents bright iridescent metallic colours. It occurs sometimes in mass, but more commonly stalactitic, coralliform, botryoidal, reniform, tuberous, cylindric, cellular, dendritic, and in pseudomorphous six sided pyramids. Its surface is smooth or granular, and is shining.—Internally it is only glistening with a lustre between pearly and resinous. The fracture of the clove-brown varieties is long and delicately fibrous; of those that incline to blue, short and coarse fibrous; of the black, very delicately fibrous passing into conchoidal; of the blackish brown, radiated; the fibres are generally more or less diverging. The fragments are splintery or wedgeshaped, sometimes indeterminately angular. It occurs in lamellar and granular distinct concretions, sometimes each concretion is granular externally and lamellar in its cross-fracture. It is commonly opake; the brownish black is slightly translucent on the edges. Its streak is yellowish-brown; it is moderately hard, brittle, and easily frangible. Sp. gr. 3.95.

It blackens before the blowpipe and gives an olive-green colour to borax. It has not been analysed; but in the smelting furnace affords from 40 to 60 per cent. of iron.

Brown ironstone occurs in the newer of the primitive mountains, but more frequently in transition and floetz mountains: it is found in veins, beds and rock masses, and is accompanied by black ironstone, spathose ironstone, brown spar, calcareous and heavy spars. It passes on one hand into red ironstone, and on the other into spathose ironstone.

It melts easily and for the most part without a flux; when one is required argillaceous schistus is generally made use of. The cast iron which it affords is not equal to that from red ironstone; but the bar iron is both very malleable and hard, probably from the manganese which it contains: hence it yields excellent steel. It occurs in great abundance in Saxony, Bohemia, and other parts of Germany; also in Tyrol, Carinthia, Stiria, Piedmont, and the South of France. It is scarcely at all to be met with in Norway, Sweden or Russia; it is found in Cornwall, and occasionally in other parts of Britain, but not in sufficient abundance to be wrought.

Spathose Ironstone.

Its colour is greyish yellow, passing into Isabella yellow and greenish-grey; it is also found hair and clove-brown, and brownish-black. It occurs in mass, disseminated, with pyramidal impressions, and very often crystallized. Its fragments are rhomboidal. It generally presents granular distinct concretions. The light coloured varieties are translucent, either entirely, or at least at the edges, those of a deep colour are opake; the former give a greyish-white streak, the latter a yellowish-brown one. It is harder than calcareous spar, and easily frangible. Sp. gr. 3.6 to 3.8.

Before the blowpipe it becomes black and magnetic, but does not melt; with borax it forms a spungy dirty yellow mass: it effervesces slowly with acids. Specimens from Sweden and Stiria have been analysed by Bergman, with the following results.

	Stirian.		Swedish.
Oxyd of iron	38	—	22
Oxyd of manganese	24	—	28
Carbonat of lime	38	—	50
	100		100

100 parts of the Stirian afforded by fusion with borax in a lined crucible 42 parts of a silvery white regulus.

It occurs in veins in primitive mountains accompanying lead, silver, and copper ores. In floetz mountains it forms beds, and is accompanied by brown iron ore, brown spar, and calcareous spar.

It is found in small quantities in Britain and the North of Europe, and is sufficiently abundant to be manufactured chiefly in the following places. At Schmalkalden in Hesse is a bed of the black variety 25 fathoms thick, which has been worked for several centuries. In Westphalia the light coloured is prodigiously abundant. At Eisenerz in Stiria, Hüttenberg in Carinthia, Jauberling in Carniola, and Schwatz in the Tyrol, are large founderies supplied by this ore. At Somororstro in Biscay is an entire hill composed of this species.

The iron obtained from this ore is particularly valuable, as it may be converted into excellent steel immediately from the state of cast iron; the bar iron formed from it is both hard and tough.

Black Ironstone. Of this there are two sub-species.

1. *Subsp.* Compact black ironstone. Its colour is between bluish-black and steel-grey. It occurs in mass, tuberous, reniform, botryoidal, &c. Its internal lustre is glimmering, semimetallic. Its fracture is conchoidal passing into fine-grained uneven. Its fragments are indeterminately angular. It forms thin and concentric curved lamellar concretions. It is moderately hard, brittle, and easily frangible. Sp. gr. 4.07.

It occurs in primitive and floetz moun-

tains accompanied by brown ironstone, spathose-iron stone and quartz. It is a rare mineral, and appears to have been found only in Saxony, the upper palatinate, Hessia, and some other parts of Germany.

It is easily fusible and yields a good iron, but corrodes the sides of the furnace. It was long confounded with the compact grey manganese.

2. *Subsp.* Black Hæmatite.

This differs from the preceding in the following particulars. Its colour inclines more to a steel-grey. Its fracture is very delicately fibrous, passing into even: the fibres are either curved or straight, bundled or diverging round a centre. The fragments are wedge-shaped. It occurs in coarse-grained distinct concretions. It has hitherto been found only at Schmalkalden in Hessia.

ARGILLACEOUS IRONSTONE.

In this are comprehended the seven following subspecies.

1. *Subsp.* Reddle or Red chalk.

Its colour is light-brownish red passing into cherry red. It occurs only in mass. Its principal fracture is fine-slaty and glimmering; its cross fracture is fine earthy and dull. Its fragments are commonly tabular, also splintery or indeterminate. The colour of its streak is similar to that of the mineral in mass, but is somewhat lighter and more shining. It soils the fingers, and may be used to write with. It may readily be cut with a knife, is easily frangible, adheres strongly to the tongue, and is soft but meagre to the feel. Sp. gr. 3.1 to 3.9.

When exposed to a red heat it decripitates and becomes black: at a high heat it melts into a greenish-grey frothy enamel.

It occurs generally in the newer argillite, forming entire beds or large imbedded masses.

In Silesia it is said to be found in compact limestone.

It is found in various parts of Germany, but is principally wrought at Thalitter in Hessia. It is never smelted for the iron that it contains, but is largely used for drawing and marking: the coarser varieties are employed by the carpenter, and the finer by the painter. What are vulgarly called Red-lead pencils, are composed of thin slips of the finer kinds of reddle inclosed in a wooden case.

2. *Subsp.* Columnar argillaceous Ironstone.

Its colour varies between liver-brown and cherry-red. It occurs in mass and in globular and angular pieces. It is dull, and has a fine earthy fracture. It forms columnar distinct concretions either thick or thin, strait or curved, parallel or diverging; sometimes they are articulated. The surface of the concretions is rough and dull. Its streak is blood-red or yellowish brown. It is soft, brittle, very easily frangible; adheres to the tongue, is meagre and somewhat rough to the touch, and moderately heavy.

It blackens before the blowpipe, effervesces with borax, and communicates to it an olive-green colour.

It is found in beds of shale, and seems in many cases to be a pseudo-volcanic product, being accompanied by porcellanite and burnt clay.

It occurs in the Upper Palatinate, in Bohemia and other parts of Germany, and has been found by Jameson in the Isle of Arran. It is by no means a common mineral, and is scarcely ever employed as an ore of iron.

3. *Subsp.* Lenticular argillaceous Ironstone.

Its colour is reddish, or yellowish-brown, brown, brownish-red, and greyish-black. It occurs in mass. Its lustre is glistening, strongly semi-metallic. Its fracture is uneven, passing into thin slaty. Its fragments are indeterminately angular blunt-edged. It occurs in small and round granular, or in compressed lenticular distinct concretions; these last are considered by many authors as actual petrefactions. It gives a slightly-shining streak, not materially differing in colour from the entire mineral. It is soft, brittle and easily frangible. The black variety is often magnetical.

According to Lampadius it consists of

Oxyd of iron	64.
Alumine	23.
Silex	7.5
Water	5.
	99.9

The red variety, which is commonly in lenticular distinct concretions, occurs in rock masses in transition mountains. The brown and black varieties, which are in granular distinct concretions, occur in beds between the variegated sandstone and the most recent shell-lime-stone.

The red and brown varieties abound in various parts of the European continent, the black has hitherto been only found in the canton of Berne.

The red affords excellent cast iron, the brown affords both bar and cast iron of a good quality; the black gives a large quantity of iron, but of a bad quality, and is difficult of reduction.

4. *Subsp.* Jaspery argillaceous Ironstone.

Its colour is brownish-red. It occurs in mass; it is internally feebly glimmering. Its fracture is flat-conchoidal passing into even. Its fragments approach more or less to the cubical form. It is moderately hard, brittle and easily frangible. The shape of its fragments, and the general resemblance of its external appearance to common jasper, distinguish it from the other subspecies.

It occurs between Vienna and Hungary in a large bed.

5. *Subsp.* Common argillaceous Ironstone.

Its usual colour is yellowish or bluish-grey, or steel-grey; frequently also yellowish or reddish brown; these colours alter much by exposure to the air and become in general deeper, nor does this change take place at the surface alone but penetrates frequently through the whole mass. It occurs in mass or disseminated, sometimes also cellular, and containing impressions of shells and vegetables. Internally it is dull. Its fracture is commonly earthy, sometimes fine-grained uneven, or flat-conchoidal, or slaty. Its fragments are indeterminate. It has for the most part only a very moderate degree of hardness. It is brittle; easily frangible; adheres a little to the tongue; is meagre to the feel. Sp. gr. 2.93 to 3.47.

It blackens before the blowpipe, and gives with borax a blackish-green glass.

It appears to consist essentially of oxyd of iron, alumine and a little silex; there is also a small variable proportion of pyrites, dispersed through it. The amount of iron which it yields in the large way varies between 30 and 40 per cent.

It occurs in beds in floetz mountains; especially in the independent coal-formation and the newest floetz-trap. The large establishments at Carron in Scotland, Coalbrookdale in England, Merthyr Tydvil in South Wales, &c. are principally supplied by this ore.

It bears a considerable resemblance to compact limestone and indurated clay, but is distinguished from them by its superior specific gravity and perfect opacity.

6. *Subsp.* Nodular Ironstone.

Its colour is yellowish-brown of various degrees of intensity: internally the colour is lighter, and it often incloses an ochre-yellow kernel. It occurs in roundish masses from the size of a walnut to that of a man's head. Its fracture is even towards the surface and fine earthy towards the centre. The external layers are semimetallic and glimmering, but towards the centre it is dull. The fragments are indeterminate. It occurs in lamellar concentric distinct concretions, often inclosing a loose kernel. The exterior layers are soft, almost friable. It is brittle, easily frangible, adheres to the tongue. Sp. gr. 2.57.

It occurs imbedded in ferruginous clay in the most recent floetz mountains, also in the floetz-trap and coal formations. It yields an iron of fine quality and is largely manufactured both in England and Scotland, especially at the places mentioned under the last subspecies.

7. *Subsp.* Pea shaped, or Pisiform, Ironstone.

Its external colour is accidental and is yellowish, reddish or grayish: internally it is yellowish-brown passing into blackish brown. It occurs in small round grains, sometimes spherical, sometimes slightly compressed. Its surface is rough and dull; internally it is dull at the centre, but acquires gradually a glistening resinous lustre in proportion to the distance from the centre. Its fracture is fine, earthy at the centre, but even towards the surface. It occurs in thin concentric lamellar distinct concretions; gives a yellowish-brown streak, is soft, not very brittle, but easily frangible.

According to an analysis by Vauquelin, it contains

Iron	30
Oxygen	18
Alumine	31
Silex	15
Water	6
	100

It occurs in cavities in secondary floetz limestone, the grains being concreted together by calcareous stalactite: it also occurs in beds of clay, and in flat beds immediately beneath the surface.

It occurs in various parts of Germany, Switzerland, France, and Dalmatia.

Its produce of metal varies from 30 to 40 per cent. It supplies very considerable ironworks at Arau near Berne, and the greater part of the French iron is said by Brochant to be produced from this ore.

Bog Iron-ore.—Of this there are three following subspecies.

1. *Subsp.* Morass ore.

Its colour is yellowish-brown. It occurs sometimes in the state of friable earthy particles, sometimes in mass, or tuberous or carious. It is dull both externally and internally: its fracture is earthy: it stains the fingers, is fine-grained but meagre to the feel; and moderately heavy.

2. *Subsp.* Swamp ore.

Its colour is dark yellowish-brown,

passing into dark yellowish-grey. It occurs in amorphous masses, also tubercular and carious. Internally it is dull, but the darker varieties are glimmering. Its fracture is earthy, passing into fine-grained uneven. It gives a clear yellowish-brown streak; is very soft, brittle, and easily frangible. Sp. gr. 2·94.

3. *Subsp.* Meadow ore.

Its colour is internally between blackish and yellowish-brown; in the clefts it exhibits a bluish-black and steel-gray tinge. It occurs massive, in rounded lumps, perforated, and tuberous. It is internally shining or glistening, with a resinous lustre. Its fracture is minute conchoidal or earthy, or even, or fine-grained uneven. It gives a yellowish-brown streak; is soft, brittle, and easily frangible.

All the preceding subspecies belong to the same formation and appear to be the most recent of any of the ores of iron. They are probably formed by deposition from water which has become charged with iron by means either of carbonic acid or the vegetable acid that is generated in mosses and marshes. The meadow ore is the oldest and the morass ore the newest.

It yields from 30 to 36 per cent of iron, well fitted for the finest kinds of cast ware. For wire or plate iron it is not qualified, on account of its being more or less cold-short, which is supposed to arise from a mixture of phosphoric acid. The usual flux employed in smelting it is limestone; it is also often mixed with red or brown ochre or hæmatite, by which the fusion of each is facilitated, and the produce improved both in quantity and quality.

Sp. 12. Blue Martial Earth.—Its colour when recently dug is said to be white, but it afterwards acquires an indigo-blue or smalt-blue, or various degrees of intensity. It occurs in mass, disseminated or investing, but always in dull pulverulent particles, more or less cohering. It stains the fingers, is meagre to the touch, and moderately heavy.

Before the blowpipe it becomes of a reddish-brown and then melts into a black shining globule, attractable by the magnet. It tinges glass of borax brown, which at length becomes dark yellow. It is readily soluble in acids.

It has been supposed by some to be native Prussian blue, and by others to contain phosphoric acid, but its analysis by Vauquelin discovered nothing except iron, alumine, and lime.

It occurs in nests in beds of clay, and disseminated in bog iron ore, or investing peat.

Green Martial Earth.—Its colour is yellowish or olive-green. It occurs generally friable and superficial; rarely in mass, disseminated or carious. Internally it is dull. Its fracture is fine-grained earthy, sometimes uneven. It stains the fingers, is very soft, meagre to the touch, easily frangible, and moderately heavy.

Before the blowpipe it becomes first red, then of a deep brown, but does not melt *per se*. It tinges borax of a greenish-yellow colour. It has been mistaken for bismuth or nickel ochre, but appears to contain no other metallic substance except iron.

It occurs at Braunsdorf and Schneeberg in Saxony, in veins.

Arseniat of Iron.—Its colour is dark brownish green, or brownish yellow. It occurs in mass and crystallized in cubes, either perfect or with the solid angles replaced by equilateral triangular planes. The planes of the crystals are smooth and shining. Internally it is glistening, with a vitreous lustre.

Its fracture is imperfectly foliated; its fragments are indeterminate. It is translucent; is a little harder than calcareous spar, and brittle. Sp. gr. 3. By decomposition it acquires a deep brownish-red colour, and at length becomes pulverulent.

Before the blowpipe it melts and gives out arsenical fumes. Its component parts, according to Chenevix, are

Arsenic acid	31.
Oxyd of iron	45.5
Oxyd of copper	9.
Silex	4.
Water	10.5
	100.0

Reduction of the Ores of Iron.—The ancient and modern methods of extracting iron from its ores differing very materially from each other, it will be necessary to treat of them separately.

Iron as it exists in the ore, whether in a state of greater or less oxydation, is capable of being brought to the metallic state when heated in contact with charcoal, by a much lower temperature than is requirred for its actual fusion, and the iron being brought to this state, the earthy matter with which it is mixed, may be vitrefied by the addition of a proper flux, so as to allow the particles of metallic iron to subside in consequence of their superior specific gravity to the bottom of the mass, although they are only in that soft pasty state which common bar iron exhibits when it is at a white heat. Now the blow-

ing machines of the ancient metallurgists being greatly inferior to those which are employed at present, they were obliged to make use only of the richest and most easily reducible ores, and even these they were never able properly speaking, to fuse in quantity; so that cast iron was a modification of this metal wholly unknown to them.

That iron which was esteemed the best was prepared in the following manner. A mass of brickwork was raised 5 feet in length and breadth, and 3½ feet high, resembling a smith's hearth, except that in the middle of this was sunk a cupshaped cavity or crucible, one foot in depth and half a foot wide, in the upper part of which was made a hole opening into a channel through the brick work. This hole being closed with clay, the crucible was filled with lighted charcoal heaped up so as to be above the level of the hearth; a blast of air was then admitted through a pipe let into the wall in the same manner as a smith's forge, and so contrived that the focus of the blast should be just above the centre of the crucible. Charcoal alone was added from time to time, till the heap became thoroughly hot, and then at the discretion of the workmen the ore, in very small pieces, unroasted but mixed with unslacked quick-lime, was laid on alternately with the charcoal. As soon as it had descended low enough to be within the immediate influence of the blast (which in a furnace of this construction would be in a few minutes) the lime and earthy part of the ore became fused into a slag, and inveloping the iron now in a metallic state, sunk down into the crucible, displacing the charcoal with which it had been at first charged. The matter remaining at rest in the crucible gave an opportunity to the particles of iron to sink to the bottom, which they did in greater or less proportion according to the fluidity of the slag and the compleatly metallic state of the iron. After this process had been going on for the space of from eight to twelve hours, the crucible became filled with melted matter: at this time the hole which had been at first stopped up with clay was opened by means of an iron bar introduced through the channel in the brick-work, and the scoriæ immediately flowed out leaving the iron behind covered with hot charcoal. The blast then being stopped, the furnace soon got sufficiently cool to allow the workmen to take out the iron, which was found imperfectly concreted together into a mass nearly of the shape of a wooden bowl: this being transferred to an anvil was first carefully hammered with wooden mallets to break off the encrusting scoriæ and render it sufficiently compact to bear the tilt hammer, to which it was next subjected: being then divided into five or six pieces, each was separately forged into a bar, and thus the operation was finished. The iron thus obtained was extremely tough and hard but difficult to work, and was in great repute for helmets and other articles of defensive armour, and in general for all purposes where toughness and hardness united were particularly required. The rich quality of the ore and the circumstances in which it was reduced, were probably the chief causes of the excellence of this kind of iron; a peculiarity however in the method of forging it may also have somewhat contributed to this; for while it was under the tilt-hammer, an assistant stood by with a ladle of water, with which he sprinkled the bar as often as it was struck by the hammer.

The poorer ores which were incapable of being smelted in the above method, were first picked, washed and roasted, then reduced to pieces no larger than hazle-nuts, and reduced (no doubt with the addition of lime) in blast furnaces from seven to eight feet high and shaped like a chimney. In these a considerably greater heat could be produced than in the former, but it does not appear that the metal when taken out of the furnace was in the state of cast iron; certain it is that it was always allowed to cool there and was never run into pigs as is the modern practice.

Some ores that are very rich and yield a soft iron, have been occasionally wrought in a manner still more simple than either of the preceding. The rich specular ore of the island of Elba in particular, appears formerly to have been worked to a considerable extent in this, which if not the earliest is certainly the rudest method that has hitherto been devised. The ore being broken into small pieces is heaped upon a bed of charcoal in a very simple reverberatory furnace. When the whole has been glowing hot for some time, the pieces being now soft and at a welding heat, are by the dexterous management of the workmen brought in close contact with each other by means of an iron bar; they are then lightly hammered while still in the furnace, and thus the whole mass acquires sufficient compactness to be removed to the anvil without falling to pieces; it is now hammered with a gradually increasing force, the earthy impurities are thrown off together with the scales of black oxyd; the lump is divided into pieces of a convenient size, which by repeat-

ed heating and hammering, are drawn into bars. The rich red hæmatite, as appears from an experiment of Mr. Mushet, is capable of being manufactured in the same way.

These ancient methods have gone into disuse, not because the quality of the iron thus produced was to be objected to, but because the time and fuel consumed were enormous, and the iron that remained in the scoriæ amounted at least to one half of the original metallic contents of the ore.

The modern methods of reducing the ores of iron are principally two; depending on the nature of the fuel made use of. In England and Scotland the fuel is for the most part coak; but in the rest of Europe, charcoal: and the processes in the founderies where the latter is employed being the most simple, we shall commence with this method

The best Swedish bar iron, named in the market Oregrund iron, from the port whence it is shipped for the market, is entirely prepared from the magnetic ironstone of Dannemora. The forges and founderies where it is manufactured, are those of Soderfors and other places in the province of Roslagia, and the most approved processes that it undergoes for this purpose are the following.

The ore in moderately large pieces, such as it comes from the mine, is first roasted. For this purpose an oblong coffer of masonry, eighteen feet long, fifteen wide and about six in depth, open at top, and furnished with a door at one of its smaller extremities, is entirely filled with logs of wood, over this the ore is piled to the heighth of from five to seven feet, and is covered with a coating of small charcoal almost a foot and a half in thickness. Fire is then communicated to the bottom of the pile by means of the door just mentioned, and in a short time the combustion spreads through the whole mass: the small quantity of the pyrites that the ore contains is decomposed by the volatilization of the sulphur, the moisture is also driven off, and the ore from being very hard and refractory, becomes pretty easily pulverizable. In the space of twenty-four hours the roasting is completed, and the ore when sufficiently cool, is transferred to a stamping-mill, where it is pounded dry, and afterwards sifted through a network of iron, which will not admit any piece larger than a hazle nut to pass. It is now ready to be smelted.

The smelting-furnace is a strong quadrangular pile of masonry, the internal cavity of which, though simple in form, is not very easily described: it may be con sidered however in general, as representing two irregular truncated cones joined base to base: of these the lower is scarcely more than one-third of the length of the upper, and is pierced by two openings, through the upper of which the blast of wind from the blowing machine is admitted into the furnace, and from the lower the melted matter, both scoriæ and metal, is discharged from time to time, at the pleasure of the workmen. The furnace is first filled with charcoal alone and well heated, after which alternate charges are added of ore, either alone, or mixed with lime-stone if it requires any flux, and charcoal: the blast is let on and the metal in the ore being highly carbonized in its passage through the upper part of the furnace is readily melted as soon as it arrives in the focus of the blast, whence it subsides in a fluid state to the bottom of the furnace covered with a melted flag. Part of the clay that closes the lower aperture of the furnace is occasionally removed to allow the scoriæ to flow out, and at the end of every ninth hour the iron itself is discharged into a bed of sand, where it forms from ten to twelve small pigs. As soon as the iron has flowed out, the aperture is closed again, and thus the furnace is kept in incessant activity during the first six months in the year; the other six months are employed in repairing the furnaces, making charcoal, and collecting the requisite provision of wood and ore.

The next process towards the conversion of pig into bar iron is refining. For this purpose a furnace is made use of resembling a smith's hearth, with a sloping cavity sunk from ten to twelve inches below the level of the blast-pipe. This cavity is filled with charcoal and scoriæ, and on the side opposite to the blast-pipe is laid a pig of cast iron well covered with hot fuel. The blast is then let in, and the pig of iron being placed in the very focus of the heat, soon begins to melt, and as it liquefies runs down into the cavity below; here being out of the direct influence of the blast it becomes solid, and is then taken out and replaced in its former position, the cavity being again filled with charcoal; it is thus fused a second time, and after that a third time, the whole of these three processes being usually effected in between three and four hours. As soon as the iron has become solid it is taken out and very slightly hammered to free it from the adhering scoriæ; it is then returned to the furnace, and is placed in a corner out of the way of the blast, and well covered with charcoal, where it remains, till by farther gradual cooling it becomes sufficiently com-

pact to bear the tilt-hammer. Here it is well beaten till the scoriæ are forced out, and is then divided into several pieces, which, by a repetition of heating and hammering are drawn into bars, and in this state it is ready for sale. The proportion of pig iron obtained from a given quantity of ore is subject to considerable variation from a difference in the metallic contents of different parcels of ore and other circumstances; but the amount of bar iron that a given weight of pig-metal is expected to yield is regulated very strictly, the workmen being expected to furnish 4 parts of the former for 5 of the latter, so that the loss does not exceed 20 per cent.

The method of preparing bar iron in all the other countries of Europe, where charcoal is the fuel made use of, is upon the whole very similar to that which we have just detailed, allowing for a few variations according to the different species of ore that are employed. But in Great Britain the number of charcoal furnaces is trifling compared with those where coak is used, and the adoption of this kind of fuel has led by necessity to a method of manufacturing iron, it is said, peculiar to that country, and wholly inapplicable to those establishments that are carried on by means of charcoal. Each method has its peculiar advantages and disadvantages; for if in quantity of produce from each forge they may claim the superiority, yet this is probably more than counterbalanced by the inferior quality of the metal, the greater multiplicity of apparatus, and consequently the larger capital laid out, and the smaller proportion of iron procured from a given weight of ore. The method, however, pursued by the British manufacturers is not a matter of choice, but has been forced upon them by the deficiency of wood. They must either almost entirely abandon this important branch of metallurgy, or substitute coak with all its inconveniences to charcoal. Thus circumstanced, much skill and ingenuity has been employed by them in overcoming the peculiar difficulties with which they have had to contend, and in making the most of the peculiar advantages connected with this mode of working, and upon the whole with so much success as to enable the British manufactured iron to enter into competition with every other kind except the very best American, Norwegian and Swedish.

The common and nodular argillaceous iron-stone are the prevailing kinds of ore made use of in the coak smelting works, partly because these are really better fitted, with this fuel, to produce iron of a good quality than the rich hæmatites of Lancashire, Cumberland and Devonshire, and partly because this kind of ore being usually found to accompany the seams of coal, it may be procured at little expence, and the same situation that is well adapted for a supply of fuel is equally convenient for abundance of ore.

The first process that the ironstone undergoes after it has been broken into pieces not larger than an egg, is roasting. This is sometimes performed in cup-shaped kilns, the bottom being occupied by lighted coals and the kiln then filled up with ore, which by the time that the fuel is consumed is found to be sufficiently torrified. The most usual way however, of burning ironstones, is the following. Upon an oblong piece of firm and level ground is laid a bed of small coal from four to eight inches in thickness; upon this is placed a stratum of ironstone composed of pieces as nearly as possible of the same size, and from 18 inches to two feet thick: the upper surface of this is then rendered more compact by filling up the interstices with smaller pieces of ore. Upon this rests a layer of small coal not more than two inches thick, and on this as a base, is reared a gradually diminishing pile of ore so as to resemble the ridge of a house; finally, the whole external surface receives a compleat covering of small coals and coal dust. The pile is kindled by applying burning coals to the lower stratum, which by degrees ignite the whole mass. The breadth of the pile at the bottom, varies from 10 to 16 feet, the usual height is about five feet, and the length varies from 30 feet to 60 yards. When the coals are consumed the pile gradually cools, and in eight or ten days may be wheeled away to the furnace.

The ore, if well roasted, will now be of a reddish brown colour, of diminished specific gravity, and will have become magnetical, the sulphur, water, inflammable matter, and carbonic acid that it originally contained, will have been dissipated, and it is now ready to be smelted.

The furnace resembles externally, a truncated quadrilateral pyramid of considerable height in proportion to its thickness. It is built of the strongest masonry, with contrivances to obviate the danger of its cracking by the expansion that takes place when it is heated. The interior of the furnace consists of the five following parts, reckoning from the bottom upwards.

First, the *hearth*, composed of a single block of quartz grit about two feet square: upon this is erected what in France and Germany is called the *crucible*, which is a four-sided cavity six feet six inches high, slightly enlarging upwards, so as to be

two feet six inches square at the top: the part above, called the *boshes* is in the shape of a funnel or inverted cone, eight feet in perpendicular height, and twelve feet in diameter at the top; this terminates in the *cavity* of the furnace which is of a conical figure, thirty feet high, and three feet diameter at the top; from this part it enlarges into a funnel shaped *chimney* about eight feet high, and sixteen in diameter at its mouth. The lining from the hearth to the top of the boshes, is composed of large blocks of quartz grit, and that of the cavity of the furnace is formed of fire bricks 13 inches long, and three inches thick. About two feet above the hearth is a round aperture called the *Tuyere*, made in one of the sides of the crucible to admit the extremity of the blast pipe, through which the air in a high state of compression is forced into the furnace; and at the bottom of the crucible is an aperture through which the scoriæ and melted metal are from time to time discharged. A furnace of this construction, if it meets with no accident, may be kept in constant work for three years or more, without requiring any repairs.

The furnace is charged at the chimney by regular intervals with coak, iron ore, and limestone, in the proportion of about 4 of the first, 3 1-3 of the second, and 1 of the third, by weight, care being taken so to regulate the frequency of the charges, as that the furnace shall be always full nearly to the top of the great cavity. The density of the blast and the form of the discharging pipe are ordered so that the chief focus of heat is about the bottom of the boshes; hence the ore has to descend about 38 feet perpendicular, before it arrives at the place where the fusion is effected. This does not happen in less than 48 hours, so that the ore is all this time in a state of cementation at a high temperature in contact with the burning fuel, and in consequence is almost saturated with carbon when it reaches the hottest part of the furnace. Being arrived at this place, the lime-stone flux, and the earthy particles of the coaks and ore run down into a slag, the iron is also melted and more or less decarbonized, and in part oxydated by the blast inversely according to the proportion of fuel with which it is mixed (for the oxygen of the air by preference unites with the loose carbon of the coak, rather than with that which has combined with the iron.) The fluid mass soon sinks down below the influence of the blast, and while it remains in quiet at the bottom of the furnace, the globules of iron are precipitated from the slag in which they were inveloped, and occupy the lowest place, while the covering of scoriæ thus interposed between the metal and that portion of the blast which is reflected downwards, prevents it from suffering any further loss of carbon. In proportion as the melted matter accumulates, the slag being the uppermost, flows out at the aperture made for this purpose, and the iron is let out at regular intervals into furrows made in sand, where it forms what is called pig iron, or into a large reservoir whence it is poured by means of ladles into moulds, forming all the various articles of cast iron ware, from cannons and steam engine cylinders, to fire grates and common iron pots.

The great object of the manufacturer is, with a given quantity of fuel to obtain as large an amount as possible of highly carburetted cast iron, as this is the kind which bears the highest price in the market: but as from various causes the iron is generally found to be more or less decarburetted, it becomes a matter of considerable importance to ascertain by external characters the principal changes induced by a progressive diminution of carbon in order that the value of any particular sample may be correctly and expeditiously ascertained. By long and careful observation it has been found sufficient for all practical purposes to arrange the several kinds of cast iron under one or other of the four following subspecies.

1. *Smooth faced Iron*, or *No.* 1. of the manufacturers. This seems to be composed of iron nearly saturated with carbon, and mixed with a comparatively small proportion of oxyd and earthy impurities. Its upper surface is smooth and convex, entirely free from oxyd, and often covered with a thin crust of plumbago: it presents a coarse granular fracture with a brilliant metallic lustre and a dark blue colour.

2. *Good melting pig Iron*, or *No.* 2 of the manufacturers. This differs from the preceding in containing probably a smaller portion of carbon and a large admixture of oxyd of iron Its upper surface is slightly convex and full of small cavities: its fracture is coarse granular towards the centre of the pig, but the concretions manifestly diminish in size as they are situated nearer the surface; its colour is dark-grey inclining to blue.

3. *Grey Iron*, or *No.* 3 of the manufacturers. In this the amount of carbon is still further diminished. Its upper surface is level, sometimes slightly concave, and presents more and larger cavities than the preceding, it is slightly oxydated superficially; its fracture is fine granular, and its colour is light grey.

4. *White Iron, forge pigs, ballast Iron.* In this the quantity of combined carbon is smaller, and the admixed oxyd larger than in any of the preceding. Its upper surface is concave, rough, and covered with a plate of oxyd; its fracture is compact sometimes tending to striated, its colour is tin-white, occasionally mottled with grey.

We shall now proceed to state in a general way, the circumstances in the smelting which principally influence the quality of the produce. Much depends on the fuel: if the coaks are not perfectly made but retain a part of their bitumen, the whole mass cakes together in the upper part of the furnace, and instead of descending regularly to the focus of heat, falls down by pieces, and at irregular intervals, so that part of the metal is detained too long before the blast, and in consequence is decarbonized and oxydated, while other portions pass so rapidly through the furnace as never to be thoroughly reduced, hence the amount of the produce is diminished and its quality greatly deteriorated. Nor is it of less importance that the coak should be perfectly dry when put into the furnace, otherwise the water which it contains will be decomposed, the hydrogen and part of the oxygen will dissolve their respective portions of carbon, and escape in a gaseous state, while the remainder of the oxygen will combine with the iron; which will thus be injured, not merely by the privation of carbon, but the positive addition of oxygen. It is further requisite that the proportion of fuel be adapted to the richness of the ore, so that there may be sufficient both to keep up the necessary degree of heat as well as to carbonize the metal: hence as the charges of ore and fuel are always proportioned by measure, if an ore somewhat richer than usual happens accidentally to be employed without a corresponding addition of fuel, the produce though somewhat increased in quantity, will be more than equivalently reduced in quality. Another circumstance that the manufacturer must carefully attend to, is the proper choice of ore with regard to fusibility, for as it is not only requisite that the iron should be melted, but also highly carbonized, and as coak gives off its carbon with much more difficulty than charcoal does, it is manifest that a very fusible ore would melt long before it arrive at the focus of the furnace, and passing rapidly through, would reach the hearth without having had time to imbibe the proper quantity of carbon. Hence it is that the rich hæmatites, although they afford an excellent quality of iron when smelted with charcoal, produce nothing but white iron when treated in the coak furnace; while on the other hand argillaceous ironstone being much more refractory, does not melt till it comes into the very hottest part of the furnace, and therefore has had full time to absorb the desirable quantity of carbon. Another thing to be attended to is the proper regulation of the blast, and this depends upon its dryness, its temperature, its compression, and its direction. The dryness and temperature appear to be principally governed by the season of the year, and therefore are but little capable of being modified by the manufacturer. It is plain that the dryer and colder the air is, the greater will be its effect on the combustion, and it is found by constant experience, that the produce of iron during the summer months is greatly inferior in quantity, and materially so in quality to that which is manufactured in the winter: a clear dry and severe frost is the most favourable period in every respect for the working of the furnace, and a change to snow or rain is infallibly followed by a corresponding deterioration. The higher the temperature of the blast is when it is delivered into the furnace, the smaller (the degree of compression and other circumstances being equal) will be the quantity of oxygen contained in every cubic foot, and of course the vigour of the combustion. Nor is the force of the blast and its direction a subject of less importance; it is obvious that in proportion as the charge descends, the carbonaceous matter is continually diminishing; hence the proper situation for the focus of the blast is that part of the furnace, where, when the ore shall have arrived it will be fully carbonized and surrounded with a sufficient quantity of fuel to excite an intense heat, and absorb nearly the whole of the oxygen of the air, and thus prevent it from either oxydating the iron, or carrying off the carbon with which it may be combined. This precise situation, in a furnace properly constructed, will be found to be just within the expansion of the boshes; but as this is more than four feet above the tuyere hole, the blast must be delivered with great velocity and in a direction somewhat slanting upwards, in order that it may be reflected by the opposite wall of the crucible, and arrive at its proper place without undergoing any material decomposition.

When the blast enters too rapidly, and in too concentrated a state, it renders the line of its passage before it is reflected so cool, that the descending slag which comes within its influence is suddenly solidified, and blown into a tube, reaching

perhaps, half way across the crucible through which the blast continues to rush, and in consequence of this protection, is conveyed with greater precision, and in a less decomposed state into the upper part of the furnace. If after this the compression of the air is somewhat diminished, the tube still remains firm, often for days together, and the furnace works in the best manner. But on the other hand, when too loose and soft a blast is admitted, and more especially if it is charged with moisture, it is unable to reach the top of the crucible without being decomposed, and the reflection which it undergoes from the wall of the crucible, weakens and disperses it to such degree, that the combustion which ought to take place within the boshes, now occupies the whole upper part of the crucible: in consequence of this, the tube of scoriæ is presently burnt away, the iron almost as fast as it is melted is ignited and oxydized, the tuyere hole glows like the sun with an intensely vivid white light; the scoria from being yellowish white, streaked with blue, becomes green, brown, and finally black, nearly the whole of the iron in the state of oxyd being taken up by it; the blocks of refractory gritstone with which the lower part of the furnace is lined are worn into great holes, and in the space of a few hours prodigious damage is sustained.

There has been no regular analysis of cast iron, but from the phenomena that take place during its conversion into bar iron, which we shall proceed to describe, it will be sufficiently apparent what are its principal constituent parts.

One of the most obvious differences between cast and bar iron, is the brittleness of the former and the malleability of the latter: this malleability has accordingly been adopted by the manufacturer as the essential character of bar iron, and as affording him a mode by which to judge of the efficacy of the means employed by him in reducing crude to malleable iron.

The first step in the process is refining. For this purpose the pigs are smelted in a refinery, (the construction of which we have already noticed) by means of charcoal; and as soon as the metal is in fusion it is let out into a mould of sand to separate the scoria that rise to its surface, and in this state is called a half bloom. As soon as it has become solid, it is again transferred to the furnace and treated as before. Sometimes even a third fusion is required before the iron shows sufficient malleability to clot into lumps when broken down almost at a fusing heat, by an iron. When it has acqured this consistency, it is taken out in moderate sized pieces, which being placed under the great forge or shingling hammer, are speedily stamped into cakes about an inch in thickness. Several piles of these cakes about a foot high, are then laid on flat circular stones, and placed in the balling or reverberatory furnace, where they are strongly heated. As soon as the whole acquires a pasty state, one of the piles is taken out by a workman and drawn under the hammer into a short bar: which being finished, is applied to another of the piles, to which it presently adheres: being then withdrawn, the new portion is welded firmly to the first by means of the hammer, and thus the bar is doubled in length; by repeating the same simple and ingenious operation the bar is made as long as its weight will conveniently allow. The cracks in the bar are then closed, and its tenacity is improved by heating it afresh in a fire made of coal, called the chaffery, (chaufferie Fr.) and again subjecting it to the action of the forge-hammer. It is now in the state of common bar iron, and ought to be entirely free from all earthy particles. After this, according to the use for which it is intended, it is transferred to the slitting mill; where it is laminated and cut up into bars and rods of various dimensions, by which its toughness and compactness is much improved, and is then ready for the smith.

The above method is called stamping; but besides this, there is another known by the name of flourishing, which requires a short notice. In this the pigs of cast iron when put into the refinery are kept for about two hours and a half in a pasty state without actually melting, and at the end of this period the metal is taken out by shovels and laid on the open floor on a plate of cast iron where it is beaten with hand-hammers in order to knock off the cinders and other adhering impurities. It is afterwards placed under the forge hammer and beaten, at first gently, till the whole mass has acquired some tenacity, and then the middle part is drawn into a bar four feet long, terminated at each extremity by a cubical lump of rough iron: in this state it is called an Ancony. It is now taken to the Chaffery, hammered afresh, and the ends being also drawn down to the same dimensions as the other part, the bar is compleated.

A third method of working iron, called pudding, was invented by Mr. Cort, (as appears from the specifications of his two patents) and is, we understand, coming into general use at Sheffield and other places. It is particularly characterised by combining the reverberatory with the

finery furnace, and the whole process is managed in the following manner. The pigs of cast iron produced by the smelting furnace are broken into pieces, and are mixed in such proportions according to their degree of carbonization, that the result of the whole shall be a grey metal. This mixture is then speedily run down in a blast furnace, where it remains a sufficient time to allow the greater part of the scoriæ to rise to the surface. The furnace is now tapped, and the metal runs into moulds of sand, by which it is formed into pigs about half the size of those which are made at the smelting furnace: and these pigs when cold are broken into pieces.

A common reverberatory furnace heated by coal, is now charged with about 2½ cwt. of this half refined grey iron. In a little more than half an hour, the metal will be found to be nearly melted; at this period the flame is turned off, a little water is sprinkled over it, and a workman by introducing an iron bar, or an instrument shaped like a hoe, through a hole in the side of the furnace, begins to stir the half fluid mass and divide it into small pieces. In the course of about fifty minutes from the commencement of the process, the iron will have been reduced by constant stirring to the consistence of small gravel, and will be considerably cooled. The flame is then turned on again, the workman continuing to stir the metal, and in three minutes time the whole mass becomes soft and semifluid, upon which the flame is again turned off. The hottest part of the iron now begins to heave and swell, and emit a deep-blue lambent flame, which appearance is called fermentation: the heaving motion and accompanying flame soon spreads over the whole, and the heat of the metal seems to be rather increased than diminished for the next quarter of an hour: after this period the temperature again falls, the blue flame is less vigorous, and in a little more than a quarter of an hour the metal is cooled to a dull red, and the jets of flame are rare and faint. During the whole of the fermentation, the stirring is continued, by which the iron is at length brought to the consistency of sand, it also approaches nearer to the malleable state, and in consequence adheres less than at first to the tool with which it is stirred. During the next half hour the flame is turned off and on several times, a stronger fermentation takes place, and a loud hissing noise is perceived, the lambent flame also becomes of a clearer and lighter blue; the metal begins to clot and becomes much less fusible and more tenacious than at first; the fermentation then by degrees, subsides, the emission of blue flame nearly ceases, the iron is gathered into lumps and beaten with a heavyheaded tool. Finally, the tools are withdrawn, the apertures through which they were worked are closed, and the flame is turned on in full force for six or eight minutes. The pieces being thus brought to a high welding heat are withdrawn and shingled; after this they are again heated and passed through grooved rollers, by which the scoriæ are separated and the bars thus forcibly compressed acquire a high degree of tenacity.

The more welding and hammering that bar iron is subject to, the tougher it becomes and the more fibrous, or nervous as the French term it, is the fracture. Hence arises the superiority of Stub iron to all the other varieties for barrels of fowling pieces and other uses where extreme toughness is required. It is prepared in the following method. A moderately broad ring of the best Swedish iron is placed horizontally and filled with old horseshoe nails (called stubs) set perpendicularly, till it can hold no more: a pointed bar of iron is then driven into the centre of the circle, and thus locks the whole fast together. A welding heat is then applied, and the mass is hammered very gently at first, till the nails and ring become compleatly united: it is then drawn down into bars and affords an iron of peculiar closeness, toughness, and malleability.

Manufacture and properties of Steel.—Steel combines the fusibility of cast iron with the malleability of bar iron, and further possesses this very valuable property, that when heated and suddenly cooled, it becomes intensely hard, and is therefore much superior to simple iron for all kinds of cutting instruments, files and various other tools. In the present section we shall describe the different methods of preparing and tempering steel, reserving for the next section an enquiry into the chemical composition of this useful substance.

The most ancient way of making steel is probably that related by Agricola. Take some highly carburetted bar iron, cut it into small pieces and mix it with pulverized scoriæ, put the mixture into a crucible lined with charcoal, and bring it to a state of fusion in a blast furnace. When both the iron and scoriæ are thoroughly fluid, immerse in this metallic bath four lumps of bar iron, weighing about thirty pounds each, and let them remain in this situation during five or six hours, stirring the bath occasionally with

an iron rod; by this time they will have become soft and spungy, upon which they are to be taken out and drawn down into bars by the forge hammer. As soon as this is performed, the bars still hot, are to be plunged into cold water, by which they will be rendered brittle, and are then to be broken under the hammer into short pieces. The crucible in the mean time is to be replenished with the same mixture as before, and when its contents are become quite fluid, the pieces into which the bars have been broken are to be again immersed till they become soft: each piece being then taken out and forged separately into a slender bar, is to be cooled while yet glowing hot, in cold water, and the process is finished. The above method is we believe entirely obsolete, though with a few modifications that are sufficiently obvious, it would in all probability be found highly advantageous.

The native steel of Eisenhartz in Stiria has always been in high estimation since the eighth century, and is prepared directly from the ore nearly in the same manner as common bar iron. The ore made use of is the Spathose Ironstone, consisting of the carbonats of iron, manganese and lime, together with a mixture of clay: it is procured in vast abundance from the neighbouring hill of Arzberg, and care is taken not to use any that has not been exposed for several years to the action of the air. No flux of any kind is necessary, and the fuel, which is charcoal, does not on an average exceed in weight one fifth of the ore. When a sufficient quantity of melted matter is collected at the bottom of the furnace it is let out into a deep mould, where it remains quiet a few minutes to allow the scoriæ to rise to the surface; this being done, a little water is sprinkled over it, which hardens the scoriæ and renders them easily removable: a second but much thinner crust of scoriæ generally succeeds, which is got rid of in the same manner. A little water is now thrown on the melted metal itself, by which its surface is suddenly covered with a congealed crust about an inch thick; this is removed, and by repetitions of the same process the greater part of the mass is thus converted into these irregular plates; what remains is a mass in the state of half malleable iron. These plates are transferred to the crusible of a refinery which has been previously lined with charcoal, and are covered with scoriæ and brought to a state of fusion, carefully observing however not to direct the blast from the bellows into the crucible, lest the iron should be decarbonized. After the whole has been in quiet fusion for some time, the fire is slackened, and as soon as the metal has congealed the scoriæ still fluid are let off. The mass is then subjected to a second fusion in the refinery with the same precautions as at first, and is now sufficiently purified to be forged: it is accordingly extended under the hammer and cut into bars which are examined by their fracture, and separated according to their qualities, into hard steel, soft steel, and steely iron: the latter is reserved by itself and used for pointing plowshares and other coarse work; but the others are made up into packets, observing to place the hardest steel on the inside, which are then drawn into bars at a lower heat than that required for iron, and then the process is compleat. Thus the whole art consists in purifying the cast iron, taking at the same time particular care that the carbon which it contains is not burnt away. If the original cast iron is very highly carbonized it sometimes happens that the steel retains too large a proportion of carbon, which is evinced in the refinery by its being more easily fusible, and requiring a longer time to become solid again than usual: this defect however is speedily remedied by adding iron filings or scraps of bar iron, the quantity of which is regulated by the degree of fusibility to be corrected.

If the manufacturer wishes to procure iron from this ore instead of steel, the only difference required in the treatment is to get rid of nearly the whole of the combined carbon by roasting the plates in a reverberatory furnace before they are brought to the refinery, and by avoiding to line the crucible of the refinery with pounded charcoal. The iron thus produced is of an excellent quality.

The best of the Swedish and Norwegian ores are occasionally wrought into steel of a very good quality by nearly the same process of manufacture, provided in the smelting a larger proportion than usual of charcoal has been employed to ensure a highly carbonized metal.

The usual method of converting iron into steel is by cementation. For the purposes of manufacture, this is performed on large quantities at a time in the following manner. Cementation or converting furnace consists of two parallel troughs, constructed of fire-brick, sufficiently long to admit with convenience a common bar of iron; these troughs rest upon a long grate from which flues proceed so as to distribute the heat as evenly as possible to every part: an arched

vault is thrown over the top, and the whole is inclosed within a cone of masonry as the glass house furnaces are. The bars of iron intended for cementation are of the very best quality, (in England none but the Swedish Oregrund iron is employed for this purpose) and are carefully examined to ascertain that they are quite free from cracks, flaws, and every appearance indicative of their not being compleatly malleable. The requisite selection being made, a stratum of coarsely bruised charcoal is laid at the bottom of the cementing trough, upon which is arranged a layer of iron bars: to this succeeds another of charcoal, and so on till the trough is nearly filled, observing that the upper as well as the lowest layer is charcoal: it is then covered with a mixture of hard rammed clay and sand in order to exclude the air. A trough thus charged will contain from seven to ten tons of iron. The fire being lighted, the heat passes into the flues and raises the temperature of the troughs to a glowing red which is maintained for the space of from seven to eleven days, according to the quantity of iron. At the extremity of each trough is a small hole, through which two or three bars project a few inches in order that they may be occasionally withdrawn to ascertain the progress of cementation: when by the trial bars, it appears to be compleat, the fire is put out, and after the troughs are sufficiently cool they are emptied of their contents. The form of the bars thus converted, remains unaltered, but their surface is covered over with bubbles or blisters, whence the steel in this state is called blister steel: it is heavier than the iron from which it was made on account of its having absorbed a portion of carbon from the charcoal with which it was in contact, though this is by no means the only action that takes place in the process of steel-making, as we shall show in the next section. Blister steel is employed only for the coarsest purposes, such as pointing horses shoes, ploughs, and other agricultural instruments, &c. By being drawn down into smaller bars under the tilt-hammer, its texture is considerably improved, and it is known in the markets by the name of tilted steel. As repeated hammering improves iron, so it does steel: hence if a bar of highly carbonized blister steel is broken into very short pieces, and these being formed into small packets, are again welded together and drawn down into bars, which being again doubled together are welded and tilted, repeating the process two or three times, the result will be a very material improvement in compactness and toughness, and the metal will be found well qualified for swords and the larger articles of cutlery: this steel has long been prepared in high perfection in Germany, whence it is called German steel; it is also known by the name of shear steel.

This is the proper place to mention the process of case-hardening, which in fact is only an imperfect kind of cementation, converting little else than the immediate surface of the metal into steel, and therefore being performed not on the rough bar but the manufactured article. The cements or carbonaceous substances used on this occasion are bone shavings or turnings, horn cuttings, and old leather shoes. The work intended to be cased having been previously filed to the requisite shape, that there may be as little occasion as possible to apply the file afterwards, is laid together with the cement in a pan of plate-iron. A forge fire is then made of considerable size, and when the upper part has caked together it is carefully lifted off without breaking, the pan is laid upon the red coals and covered with the caked mass. In this state it remains for nearly two hours, without urging, the fire. Small pieces of iron wire that have been previously introduced into the pan being withrawn from time to time, are dipped while hot in cold water, and by the file and the character of the fracture, the progress of the cementation is determined. When the intended degree of carburation is obtained, the fire is increased and the articles as soon as sufficiently heated are taken out of the pan and plunged in cold water. The inferior kinds of table-knives and some surgical instruments, where a considerable degree both of toughness and hardness is required, are prepared in this way.

The finest kind of steel however, called English cast steel, yet remains to be mentioned. It is commonly prepared by breaking to pieces the blister steel and then melting it in a crucible with a flux composed of carbonaceous and vitrefiable ingredients. When thoroughly fused it is cast into ingots, which by gentle heating and careful hammering are tilted into bars. By this process the steel becomes more highly carbonized in proportion to the quantity of flux, and in consequence is more brittle and fusible than before; it is inferior to the other kinds of steel in being incapable of welding either with iron or steel, but on the other hand surpasses them all in uniformity of texture, hardness, and closeness of grain, hence it

is the material of all the finest articles of English cutlery. The composition of the flux used in preparing this steel is kept a secret among a few manufacturers, and in consequence various experiments have been instituted both here and elsewhere to discover either the same or an equally successful method of making this beautiful substance. In 1795, Clouet published the results of some valuable experiments, from which it appears that by simply fusing bar iron with charcoal a cast steel may be obtained more or less carburetted, according to the proportion of charcoal employed, and therefore possessing at pleasure in a greater or less degree the qualities of fusibility, brittleness and hardness: he also showed that the same effects may be produced by fusing bar iron with glass and charcoal, or the black oxyd of iron with the requisite proportion of charcoal alone, or by keeping in fusion for about the space of an hour a mixture of small bits of iron and equal parts of clay and marble or any other calcareous carbonat. In 1800 Mr. Mushet took out a patent for preparing cast steel of various qualities by fusing bar iron with different proportions of charcoal, coinciding for the most part with the facts and principles before laid down by Clouet, and confirmed by his own experiments; but whether the steel thus prepared is equal to the finest cast steel of Huntsman, has not we believe been as yet compleatly ascertained.

Steel is rendered hard by heating and then suddenly cooling it. The degree of hardness which it is capable of acquiring is in direct proportion to its fusibility, or in other words to the quantity of carbon with which it is combined; and the degree of hardness which in any particular instance is actually given to it is in proportion to the difference of temperature between the medium in which it is heated and that in which it is cooled; modified however by the capacity for heat and the conducting power of the cooling medium. Thus if steel is heated somewhat below the degree at which it melts and then transferred into oil at the temperature of 200°, the hardness thus acquired will be inferior to that which would have been obtained if water, or still more so if mercury, at the same temperature had been made use of. Again, if instead of oil at 200° the same fluid at 40° had been employed, a greatly superior degree of hardness would have been produduced.

The hardness acquired by this method has generally been thus accounted for. The particles of the metal by being heated are placed at a greater distance from each other than before, and in proportion as this heat is again abstracted, the attraction subsisting between them will become efficacious, and they will approach nearer to actual contact; but the impetus with which this takes place will be in proportion to the difference of temperature, and therefore when red hot steel is plunged in ice-cold mercury, the force or resilient spring of its particles will be greater than if mercury at 200° had been made use of, and consequently its hardness will also be greater. But this theory however ingenious, is opposed by certain facts which perhaps may be found more consonant with the following explanation of them.

If we take the specific gravity of a piece of steel, both when hardened and after it has been softened, by heating again and gradually cooling, we shall find that its bulk in the former case is greater than in the latter, whereas if the hardness of steel was owing to the rapidity and energy with which its particles collapsed on cooling, directly the reverse of this ought to take place, the state of greatest hardness should be that of the greatest specific gravity. So in like manner we find to be the case with glass; if a little of this in a melted state is dropped into cold water it will prove very hard and brittle; but if the same piece is again heated red (without however in any degree softening it) and afterwards allowed to cool gradually, its specific gravity will have very notably increased, and it will have become tough and elastic. We may therefore consider the hardening of steel to be caused by the contemporaneous expulsion of part of its heat and the fixation of its particles before they have had time to arrange themselves and contract upon each other. Hence on the impression of any external force, the particles that are struck are not able to slide on each others surfaces, and thus distribute the impetus which they have received over the contiguous ones; or in other words the mass becomes *harder* than it was before, hence also the whole force of a blow is borne by a comparatively small number of insulated particles, and these entirely giving way before a degree of percussion that might easily be sustained by the whole when combined, thus produce the quality of *brittleness*.

If highly carburetted steel is made nearly as hot as it can bear without melting, and is then plunged in very cold water, it is apt to fly to pieces, and even if this does not take place, the metal is not applicable to any use in this state of extreme hardness, for the particles are plac-

ed so far asunder that the whole has a strong tendency to become crumbly, and will not bear a fine even sharp edge. In the practice of the best manufacturers the hardening heat even for files, which are the hardest of all steel instruments, is not greater than a red visible by day-light; and all cutting and elastic instruments require to be much softer. The various degrees of hardness necessary for different articles are not however given, as might at first be supposed, by the simple process of hardening at the requisite temperature, but by the compound method of first giving to every article nearly a file hardness, and then, by the subsequent process of *tempering*, reducing the hardness to the particular degree necessary for each article

Tempering consists in softening hardened steel by the application of a heat not greater than that which was employed in hardening it; for this purpose it is gradually heated more or less according to the temper required, and cooled again either gradually or rapidly, this making no difference, after which the steel is found to be softened or tempered exactly in proportion to the heat which it has undergone. While the steel is tempering its surface displays a succession of colours (supposed to arise from a commencing oxydation) in proportion as it becomes more and more heated, which the workmen in this metal have ingeniously taken advantage of, as indicating and serving to denominate the degree of temper required for different articles. The first perceptible colour, is a light straw yellow, and this being produced by a small degree of heat, indicates the highest or hardest temper; to this succeeds a full yellow, then a brown, afterwards a reddish blue, then a light blue, and lastly a full deep blue passing into black, which being the other extremity of the series denotes the lowest degree of temper and a hardness only a little superior to what the piece of steel would have acquired if when heated for the purpose of being hardened it had been allowed to cool gradually instead of being plunged into a cold liquid. The old method of tempering, and which indeed is still practised by most manufacturers, is to lay the articles on a clear coal fire, or on a hot bar, till they exhibit the requisite colour; but small articles which were to be reduced to a blue temper were commonly blazed, that is they were first dipped in oil or melted grease, and then held over a fire till the oil became inflamed, and thus evaporated.

Some particular articles require a nicety of temper that is not very easily attained by trusting merely to the change of colour, a circumstance that induced Mr. Hartley, in the year 1789, to take out a patent for a new and more accurate method. For this purpose a mercurial thermometer graduated as high as 600° is to be immersed in an iron trough heated by a furnace or lamp placed below it and filled with fusible metal, upon the surface of which the steel is to be laid, which may thus be tempered with great accuracy at any degree of the thermometer that the artist chuses. Oil may be substituted to the fusible metal, and the effect will be the same, except that the steel being in this case tempered beneath the surface of the liquid, and of course out of the contact of atmospherical air, will not exhibit those changes of colour which take place when the other methods are employed. The following table shews the temperature at which the various colours make their appearance.

430° to 450° indicates the several tints of straw colour, and is the temper for razors and those instruments which have a stout back supporting a keen and delicate edge.

470° corresponds with the full yellow, and is the proper temper for scalpels, pen-knives, and other fine-edged instruments.

490° indicates the brown yellow, and is the proper temper for scissars and small shears.

510° indicates the first tinge of purple, and is the temper for pocket and pruning knives.

530° indicates purple, and is the temper for table and carving-knives.

550° to 560° indicates the different shades of blue, and is the temper for watch-springs, swords, and all those instruments in which great elasticity is required.

600° corresponds with black, and is the lowest degree of temper.

One great advantage attending the use of cast steel is its uniform quality: the carbon which it contains appears to be equally distributed through every part of the same mass in consequence of the fusion that it has undergone: whereas both the natural steel and the steel of cementation are apt to contain veins of iron, either quite soft or at most very slightly carburetted, and thus a degree of imperfection and uncertainty is introduced extremely mortifying to the artist, and not unfrequently the occasion of much labour in vain. It is therefore no small benefit which Mr Nicholson has conferred on the workers in iron and steel by publishing a simple and effectual method of ascertaining whether any particular bar is pure iron or steel, or a mixture of both. The surface of the metal being cleaned with a file or with emery paper, is to be spread over with very dilute nitrous acid, by which the iron will be dissolved, but the carbon will remain behind untouched; after therefore the acid has been allowed to act for a few minutes, the bar is to be put into clean water and moved about in it gently, that both the residual acid and the nitrat of iron may be washed away, care being taken not to touch the surface with the hand or any thing else that may rub off the carbon. The bar thus washed, if pure iron, will exhibit an uniform iron-grey colour; if it is pure steel, the colour of the surface will be black, the iron having been taken up by the acid and a thin coating of carbon remaining; but if it is a mixture of iron and steel the surface will be dotted or streaked, those parts which are steel being of a dull black, and those which are iron exhibiting the usual colour and lustre of this metal.

Steel being considerably more expensive than iron, it is customary in making the larger and coarser kinds of cutting instruments to form only the edge of steel. The two bars of iron and steel are first welded together and afterwards forged into the requisite shape in the usual manner. Highly carbonized steel is however incapable of being thus united to iron, because the same temperature at which iron welds freely is that at which this kind of steel enters into fusion, and therefore the first stroke of the hammer will entirely shatter the steel and disperse it about in small fragments. This however is a difficulty which it is well worth while taking some pains to overcome, as the efficacy and durability of instruments thus composed materially depends upon the goodness of the steel. The most effectual way hitherto discovered of uniting together iron and highly carbonized steel, is that published by Sir Thos. Frankland. The iron is to be raised to a welding heat, in one forge, and the steel is to be made as hot as it can bear without becoming very brittle in another; both pieces are then to be quickly brought to the anvil and made to adhere together by gentle hammering.

Several curious pieces of work are made of iron and steel welded together, especially the real Damascus sword blades, which are believed to be composed of slips or thin rods of iron and steel bound together with iron wire, and the whole firmly cemented together by welding. The properties and external appearance of such a blade correspond very exactly with the supposed mode in which it is manufactured. Its colour is a dull bluish grey; it is scarcely harder than common steel from the forge; it is not easily bent, and when bent has no elasticity to recover its original figure; but the circumstance which principally characterizes it is the appearance of narrow waving lines, not crossing each other, and chiefly running from heel to point; they are ill-defined and about the thickness of a harpsichord wire. This wavy appearance is not produced by any perceptible indentation of the surface, but merely by a slight difference in the degree of polish or brightness, and therefore may be at once distinguished from the false damasking or etching, by which other sword-blades are made to resemble the genuine Damascus ones. In the false Damascus blades the waving lines, called the *water*, are obliterated by grinding; but in the real ones, although the water is at first imperceptible after grinding, yet it may at any time be made to reappear by rubbing the blade with lemon juice, no doubt on account of the unequal action of this weak acid on a surface composed both of steel and iron.

Besides the varieties of steel that we have already described, there yet remains one more, concerning which a few words will be necessary: this is Wootz. The substance known by this name in India, is imported into this country in the form of round flat cakes about five inches in diameter and one inch in thickness. When cold it is uncommonly refractory, neither breaking nor bending under the hammer. It is not nearly so easy to be filed as either bar or cast steel before these have been hardened: it takes an extremely high brilliant polish; its fracture is moderately close, resembling that of blister steel that has been heated and hammered a little. When nearly white hot it is malleable, but is much more likely to crack under

this treatment than even cast steel: it requires, therefore, much care, labour, and time, to fashion it into any required shape. When made white hot, it exhibits the glassy smooth surface of welding iron; but, when struck very gently with a hammer, it cracks in many places, and by a harder blow is shivered to pieces. When brought to a high heat and quenched suddenly in cold water, it becomes harder than at first, though not equally so with the finest cast steel in similar circumstances; but, on the other hand, it is not capable of being sensibly softened by annealing as the other varieties of steel are. At a high heat it is fusible, and after being melted, exhibits a close compact grain, is considerably brittle, and bears a very near resemblance to cast steel. From its analysis and other circumstances, it is considered by Dr. Pearson as differing from steel only in containing a little oxyd of iron.

Comparison and analysis, of Cast Iron, Bar Iron, and Steel.

Notwithstanding the close attention of various eminent chemists to this important subject, much yet remains to be done before an entirely satisfactory theory can be formed, to account for the different properties possessed by the various kinds of iron and steel. We shall endeavour to show in the present section the progress that has already been made in this interesting analysis, and shall then point out some of the chief difficulties that yet remain to be overcome.

In all the varieties of iron and steel, the principal ingredient is metallic iron, and as this metal in the reguline state alone, has the property of giving out hydrogen gas while dissolving in dilute sulphuric or muriatic acids, the amount of inflammable gas thus produced, has been adopted by Bergman, by Berthollet and Pearson, as upon the whole the most satisfactory and compendious exponent of the quantity of reguline iron contained in any of the known varieties and forms of this metal. Thus a mixture of equal parts of reguline and oxydized iron, by treatment with dilute sulphuric acid, will produce only half the quantity of hydrogen gas, that an equal weight of pure iron would. But this can be admitted to be a perfectly accurate mode of proceeding only where the mixture thus analyzed, contains nothing that is soluble in hydrogen gas at the temperature, and in the other circumstances under which the experiment is performed. None of the kinds of manufactured iron is entirely free from carbon; and this, according to Berthollet, is taken up by the nascent hydrogen as the metal dissolves in the acid; whence originates a material source of error, the quantity of gas produced depending not merely on the proportion of iron, but also of carbon in the mixture. It appears from Berthollet's experiments, that when cast iron or steel is treated by dilute sulphuric acid, at a boiling temperature, in proportion as the metal dissolves, a black spungy matter is observed floating in the solution: the quantity of this increases till the process is about half over, then it begins to diminish, and will be found to have entirely disappeared by the time that the last portions of iron have dissolved. This black matter is carbon, which being insoluble in sulphuric acid or sulphat of iron, must necessarily have been taken up by the hydrogen. This, accordingly, is found to be the case; for the gas produced, requires a greater proportion of oxygen for its combustion, and the result of the process is a quantity of carbonic acid. This is further confirmed by an observation of Rinman's, that the inflammable gas arising from the solution of steel, affords by combustion more fixed air, than that which is produced from the solution of bar iron. From the numerous experiments of Berthollet on this subject, we have selected the six following as sufficient for our purpose, and having converted the weights and measures into English, it appears that at 29.84 Bar. and 59° Fahr.

Grs.		
100 of grey cast iron yield with diluted sulphuric acid	104.8	oz. measures of inflammable gas.
100 of bar iron made from the preceding	111.5	do.
100 of Steel from the preceding	108.3	do.
100 of Swedish bar iron	114.	do.
100 of Steel from the preceding	106.7	do.
100 of white cast iron from Eisenerz	97.4	do.

It might at first be supposed that a given quantity of hydrogen would increase in bulk in proportion to the carbon taken up by it; the reverse of this, however, is in fact, the case: therefore, if Swedish bar iron be considered as the pure state of this metal, represented by the number 114, the proportion of iron contained in an equal weight of steel made from the same, will be more than 106.7, because the former number indicates pure hydrogen, but the latter carburetted hydrogen.

Dr. Pearson on the other hand, in his experiments on wootz, assures us, that when dilute sulphuric acid is acting on steel at the common temperature, a quantity of black carbonaceous matter is separated, which continues to augment so as to impede the effect of the acid; if at this period a lamp is applied, the increased temperature brings on a more rapid action, and the black sediment appears rather to diminish in quantity. This diminution however, Dr. P. attributes only to the solution of the iron with which the carbon was combined, and not to the solution of the carbon itself in the hydrogen: for, says he, the gas when burnt with oxygen procured from manganese, inflamed like common hydrogen, and whether procured by means of iron, or steel, or wootz, produced only a very slight turbidness with limewater; whereas, carburetted hydrogen, prepared by passing steam through hot charcoal, being treated in the same manner, rendered the limewater quite milky. The proportions of gas from iron and steel, were also remarkably less than those mentioned by Berthollet. 100 grains of wootz, by several experiments, yielded from 78 to 84 ounce measures of gas. 100 grains of steel wire, also by various experiments, yielded from 83 to 86 ounce measures of gas. 100 grains of iron wire yielded from 86 to 88 ounce measures.

How much soever the experiments of Berthollet and Dr. Pearson differ in other respects, yet we may infer that Swedish bar iron contains a larger proportion of reguline iron than the other varieties of bar iron; that steel contains a smaller proportion than bar iron, that wootz contains a still smaller proportion, that grey cast iron is inferior in this respect to steel, and that white cast iron is the least pure of any.

We also learn, that the lower the temperature is, at which the solution of the iron is made, the purer is the hydrogen that is produced; and with proper care, that the objections raised by Berthollet, to the accuracy of this mode of proceeding, may be compleatly done away.

We have already mentioned that almost all the known varieties of iron and steel contain a larger or smaller proportion of carbon. The quantity of this in any particular sample of metal may best be ascertained by digesting the metal in dilute nitro-muriatic acid, which will leave untouched the carbon united with a little iron. This black insoluble residue being washed in warm water, and finally digested for a minute in weak ammonia, should be heated in a flask almost to redness, to expel the water and any muriat of ammonia that it may contain; being then weighed it is to be ignited in a silver or platina crucible till the whole of the carbon is burnt off, and the residual iron is oxydized: from the weight of this oxyd is to be deducted 48 per cent. on account of the oxygen, and the difference between the weight of the remainder and that of the black powder before ignition indicates the amount of carbon.

The affinity of iron for carbon is pretty considerable, though it is by no means capable of decomposing carbonic acid by combining with its base, as Mushet has clearly shewn in opposition to the assertion of Clouet.

The effects produced upon iron by carbon are very remarkable. First with regard to colour: the bluish grey tint of iron becomes more and more white in proportion as it combines with carbon, till it possesses almost a silvery colour and lustre, as is the case with the white cast iron, in which state the metal seems to be saturated with carbon. At the same time that these changes of colour are going on, the tendency to crystallization is rapidly increasing; hence the fracture from being fibrous and hackly, becomes first compact, then granular, and at length exhibits facets like antimony. With these changes the fusibility increases, and the faculty of welding diminishes, and soon entirely ceases: the ductility and malleability also undergo an analogous change, though not quite to so great an extent: the hardness increases, as also does the property of induration by sudden cooling, and the capability of being tempered.

Iron however may not only be saturated but supersaturated with carbon: that is to say, when at a very high temperature it will dissolve more carbon than it can hold in solution at a lower temperature; and in consequence, by slow cooling while it is still fluid, a part of this excess of carbon will separate from the rest of the mass and rise to the surface, forming a flaky crust of plumbago or carburet of iron. Some however of the plumbago will still remain inveloped by, and disper-

sed through the iron, giving it an uniform dark grey or black colour if the proportion is considerable, or only mottling it if the excess of this substance is very slight.

The actual proportions of carbon contained in the different kinds of iron have not yet been ascertained with any accuracy either by analysis or synthesis; but thus much appears certain, that bar iron in general contains a smaller quantity than the softer varieties of steel, and these again always contain less carbon than the common and finer cast steel; that in the white, the mottled, the grey, and the black varieties of cast iron, the dose of carbon is constantly augmenting, in the last of which the proportion of carbon is probably about one-twentieth of the whole.

Oxygen is also contained in most of the varieties of iron, and the effects occasioned by it in the different processes to which this metal is subjected, require more attention than has hitherto been paid to them. Cast iron appears to be highly charged with oxygen, and on this account requires to be supersaturated with carbon in order to be converted with any economy into bar iron. It may seem at first a paradox to maintain the coexistence of oxygen and carbon in the same metallic mass, especially considering the great heat to which it is exposed in the process of reduction, since it is an universal and uncontroverted fact that metallic oxyds are decomposed by carbon at a high temperature, the oxygen and carbon uniting together and being dissipated in the form of gas, the metallic regulus remaining behind. But when the roughness of the smelting process in blast furnaces, and the large quantity of materials operated on at once, as well as the great pressure of the superincumbent scoriæ are taken into consideration, we shall cease to be surprized at the apparent anomaly. The existence of oxygen in cast iron, is manifest from the phenomena that accompany the operation of puddling, as already described in a preceding section. The crude iron being subjected to a high temperature, under a pressure no greater than that of the atmosphere, the oxygen and carbon that it contains react upon each other and produce carbonic acid and gaseous oxyd of carbon, which having escaped, the metal is found reduced to a state of malleability. The same effects take place in close vessels, as Dr. Beddoes has well shewn. If crude cast iron is put into a retort, as soon as the vessel and its contents have acquired a low red heat, an inflammable gas mixed with carbonic acid is given out with considerable rapidity (this inflammable gas must from the circumstances be the oxyd of carbon) when the production of gas ceases, the iron upon examination will be found to have lost somewhat of its weight, and to be nearly in the state of bar iron. But though this combination of the oxygen and carbon of the crude metal, and the consequent generation of air takes place with great ease when the beak of the retort is but just dipped under water, yet if the pressure amounts to five inches of water, in addition to the atmosphere, the disengagement of air proceeds very slowly, and entirely ceases if instead of the water a single half inch of mercury is employed; although upon removing this obstacle the bubbles of air pass through as before.

By the treatment that cast iron undergoes during its conversion into malleable bar iron, the greater part of the oxygen and carbon is got rid of; still however a small quantity of oxygen, the smaller in proportion to the goodness of the iron, remains. This is inferred with much probability from the blistered appearance that the bars of iron exhibit after having been converted into steel by cementation. These blisters are manifestly occasioned by the exudation of a gas from the bar, and this gas in all probability is oxyd of carbon. A further proof of the existence both of oxygen and carbon even in Swedish bar iron may be deduced from some interesting experiments by Mr. Mushet. Having put some pieces of Swedish bar iron into an earthen crucible, with a flux composed of marble and calcined clay, he observed first, that the earths melted together before the iron showed signs of fusion, and that while this latter was melting, bubbles of air were continually rising from it and passing through the vitrified flux: this gas burnt with a lambent blue flame, and probably was gaseous oxyd of carbon: the iron sustained a notable loss of weight, and had become considerably softer than at first.

Steel, probably, is entirely free from oxygen.

The action of vitrescent earthy mixtures comes next to be considered. It is certain that cast iron contains a very considerable proportion of scoriæ diffused through its substance, which are partly got rid of by subsequent fusion, as they rise to the surface of the metal, being considerably lighter than it, while such portions as still remain are got rid of for the most part, by hammering and laminating during the conversion of the cast iron into bar. A very small proportion of scoriæ however is not unfrequently left in the iron, as is obvious from the earthy residue

that some of the varieties of this metal leave behind them when dissolved in acids. It is not yet clearly made out what is the precise effect of a little earth on the malleability of iron. Clouet has endeavoured to show that it renders the iron softer and more malleable, but inclined to be hot short, and the experiment by which he demonstrates it is the fusing together of iron and glass, by which the effects just mentioned are produced upon the metal. But this is precisely the same experiment as that of Mr. Mushet's related in the preceding paragraph, and M. Clouet having entirely overlooked the extrication of gas from the metal, has gratuitously attributed the change produced to a combination of the iron with a little of the glass, without, as appears, taking the trouble to substantiate his hypothesis by actual analysis.

Cast iron made with coak instead of charcoal must necessarily contain a variable proportion of sulphur, nor is this substance very likely to be entirely dissipated by the subsequent refining that the metal goes through; and it appears from a direct experiment by Dr. Beddoes, that iron, after being puddled and stamped, if treated with muriatic or sulphuric acid, will give out sulphuretted hydrogen. Bergman has shewn that certain varieties of iron contain manganese, and others phosphoric acid. Clouet has detected arsenic in some; and other chemists have somewhat obscurely intimated the presence of lead, copper, and zinc; which is far from improbable, as several of the ores of iron are occasionally mixed with galena, copper pyrites and blende. But the effect of these substances in small quantity on iron has not yet been ascertained by any experiments that can be depended on; it is therefore obvious how much remains to be done before we acquire a thorough knowledge, even on practical points, of this most important of all metals.

The following, in the present state of our researches on this subject, may be laid down as the essential characters of the principal forms under which iron exhibits itself. Crude cast iron besides casual impurities contains carbon, oxyd of iron, and vitrified earth. The difference between white, mottled, grey and black cast iron depends on the proportion of carbon, which is smallest in the white and greatest in the black. By the process of refining or resmelting, most of the earth and oxyd of iron rises to the surface of the metal in the form of a dense slag; hence the residual iron differs from the crude pig-metal in containing less earth and oxyd. By the subsequent operations the carburet and oxyd of iron mutually decompose each other, forming carbonic acid and carbonous oxyd, by which the metal is freed both from its oxygen and carbon. In this state it forms bar iron, which may or may not retain a small proportion of vitrified earth, but which seems even when purest to hold a little both of carbon and oxyd. If this bar iron is exposed in a close vessel to a high heat, the carbon and oxygen that it contains (if they are in due proportion to each other) will be entirely got rid of; the metal will become very soft, and will be at the same time malleable and fusible. If the bar iron instead of being heated by itself has access to carbon either in the state of charcoal or plumbago, its oxygen will be expelled and carbon will at the same time be absorbed: if the portion of this latter is small, the mixture will partake of the properties both of iron and steel, hence it will be very malleable and capable of being welded, but also will be harder than pure iron, somewhat more fusible and susceptible of being tempered. By being united with a fresh portion of carbon it will become still more fusible and will lose its welding property; it will become harder, more compact, and will form the fine cast steel. A further portion of carbon increases the brittleness and hardness, so as to render it incapable of being wrought, and its colour and texture will approach to that of white cast iron: in this state it may be regarded as saturated with carbon. It is however capable of uniting to this substance even to supersaturation, by which its colour and texture resembles that of grey or black cast iron; its fusibility is somewhat increased, but its hardness is so much lowered by this excess of carbon as to allow it to be wrought with ease by a common file, nor can it be materially hardened by sudden cooling or be tempered, so that it is no longer in the state of steel. By a still further cementation with charcoal it would in all probability be converted into plumbago.

Many chemists have supposed that supercarbonized steel is the same thing as crude iron, because they resemble each other in their fracture and colour, and contain carbon; and upon this reasoning have been founded several imperfect and ineffectual methods of applying the finer kinds of cast iron to some of the uses of common cast steel; but we have shewn that however great may be the resemblance in some points, yet cast iron essentially differs from steel in containing both earth and oxyd of iron, and therefore cannot be substituted for it with any success.

It only remains to say a few words concerning two states of bar iron called hot-short and cold-short.

Iron that is hot-short or red-short is very soft and ductile when cold, on which account it is generally employed in the manufacture of wire; it may also be hammered and welded if treated skilfully at a full white heat, but when it has cooled down to a cherry red, it breaks away before the hammer and is dissipated almost like sand.

Cold-short iron on the contrary is harder not only than hot-short but also than pure Swedish bar iron; it may be wrought in the usual way when red or white hot, but possesses no toughness when cold; so that a large bar may with ease be broken across by a common hand hammer

Hot-short iron is imagined, rather than proved, to contain arsenic, to which its brittleness at a red heat is supposed to be owing.

Cold-short iron is supposed by Bergman to derive its characteristic qualities from a portion of phosphoric acid; and it is certain that phosphat of iron has been found in iron of this description, both by the illustrious Swedish chemist just named and Meyer and Clouet.

If however it be granted that hot-short and cold-short iron respectively contain arsenic and phosphoric acid, yet it must in return be allowed that these qualities appear in very many cases where there is no reason to suspect either the one or the other, and that the methods by which these defects may be produced or remedied are in many cases at least not very reconcileable with their supposed origin.

If white cast iron, that is, such as is deficient in carbon, be exposed to the action of a current of flame after it has exhibited its proper degree of malleability, it will pass into the state of cold-short iron, and its brittleness will increase in proportion to the length of time that it is thus exposed. Does it not therefore seem probable that in many cases at least the defects of cold-short iron are occasioned by an absorption of oxygen? This however the advocates for the universality of Bergman's theory on this subject may allow with perfect consistency. They would say that the phosphat of iron originally contained in the ore is converted by the process of smelting into phosphuret of iron, which being capable of uniting perfectly with bar iron and forming only a very small proportion of the whole, may render the iron hard without materially impairing its toughness while cold: but when this iron deprived of carbon is exposed at a high temperature to the action of the air, the phosphorus becomes acidified, and the phosphat of iron that hence results being incapable of combining with malleable iron is merely dispersed through it, and must therefore tend to render it brittle. Nor is the explanation of the fact contradicted by the methods made use of to correct this quality. Rinman says that cast iron, which by the common treatment would yield cold short bar, may be made to afford soft malleable iron by fusing it with a mixture of equal parts of lime and scoriæ. Mr. Mushet says that 875 grains of cold short iron when melted by itself in a covered crucible formed a perfect button covered by a thin film of brown glass. The metal weighed only 805 grains, and instead of being cold-short, was now found to have acquired the opposite fault of being hot-short, it was extremely soft and ductile. In these experiments it may be said that the metal being brought to a state of quiet fusion, the phosphat of iron either entirely or at least for the most part separated in the form of glass from the reguline portion. But as all the above phenomena may be accounted for equally well upon the supposition that the cold-short quality is owing simply to the mixture of oxyd of iron with the metal, it would be useless to speculate further on the subject till a sufficient number of accurate analyses have been performed to direct our investigations. The hot-short quality appears to be occasioned by the admixture of some substance which enters into fusion at a low red heat, and thus destroys the tenacity of the iron through which it is diffused: hence this variety of iron cannot bear the hammer at a red heat, though when the temperature is raised to the full welding point, the effect of this unknown substance is counteracted by the tenacity which the particles of iron then acquire. This substance has been by some supposed to be carbon, but this is inconsistent with the extreme softness which always characterises hot-short iron: for the same reason it cannot be phosphorus. The effects are more like those of a metallic body; and lead, arsenic, copper, and zinc may be each suspected with almost equal probability. In some varieties of hot-short iron, especially those made with coak, the fragility increases with the increase of temperature, and they are wholly incapable of welding: this probably arises from a large admixture of the same substance, whatever it be, to which the more usual characters of hot-short iron are owing, with perhaps a little sulphur.

Manufacture of copperas.—The sulphuric acid dissolves iron, and forms the well

known salt Sulphat of iron, Green vitriol, Green copperas, or Sal martis. The greater quantity of this salt which is used in manufactures of various kinds, particularly in dyeing black, is not prepared from the direct combination of its ingredients, but from various kinds of native sulphurets of iron or pyrites (already described in this article) after they have undergone spontaneous oxygenation by long exposure to air. Green vitriol is prepared in many counties in England; the first manufacture of the kind was undertaken in the reign of queen Elizabeth, at Deptford, where it is still carried on. It is likewise made largely in Northumberland and Durham. The method of manufacture is simple, and scarcely differs now from what it was more than a century ago as described by Colwall.

The following is the process actually in use.

"The usual mode of manufacturing copperas on the rivers Tyre and Wear, is by exposing iron pyrites (there called brasses) which are found in the collieries, to the influence of the atmosphere. For this purpose a situation is chosen inclining towards the river, of a natural strong clay. After the soil is taken off, gutters are cut in different directions, and wells of about 5 or 6 feet deep, and 2 or 3 in diameter, are sunk where the gutters terminate. Upon this surface the brasses are laid to the thickness of 4 or 5 feet. The vitriolization shews itself in a white efflorescence, which is washed off by the rain into the gutters and conveyed by pipes from the wells to a reservoir, from which there is a pipe of communication to the boiler. This is a leaden vessel generally about 7 feet deep, 12 to 14 long, and 6 or 7 wide, where the liquor is evaporated for 6 days, during which time a quantity of old iron is added to it, as much as it will dissolve. It is then run into a crystallizing vessel, and remains there for five weeks, at the end of which time the mother liquor is run into a reservoir, and pumped back into the boiler, and the crystals are removed, and after being well drained are packed in hogsheads for sale. A single boiling from a boiler of the above dimensions yields from 5 to 8 tons of copperas, according to the strength of the liquor."

Vitriol is made near Haguenau on the Rhine nearly in the same manner, according to the description given by Cavillier. The pyrites is disposed on an inclined soil in beds about two feet thick, beneath which are gutters going to a common reservoir. The vitriolization of pyrites is always seen by whitish efflorescences tasting strongly of vitriol, at the same time that the surface of the pyrites cracks in every direction. When the season is dry it is occasionally watered to carry off the vitriol already formed, and to promote a fresh vitriolization in the remaining ore. The heaps are found to be exhausted when these saline efflorescences are but scanty, and when the lump (when broken) appears changed throughout into the liver pyrites.

The vitriolic liquor is evaporated as usual in lead boilers, but it does not appear that old iron is regularly added to saturate the liquor as in England, but only occasionally when it appears too acid. Some of the mother liquor of the former operation is always added.

The evaporated liquor before it passes into the crystallizing pools is sent to another bason, where it remains for twenty-four hours to deposit a large quantity of ochre. The crystallizing pools are made of fir planks surrounded with beaten clay. It requires ten days for the solution to deposit all its crystals, part of which is collected on sticks put into the vessel, but the purest vitriol is deposited the last. The liquor that remains after the deposition of the crystals (or the mother water as such liquors are always termed) is reserved, and a portion is always added to the boiler in the next evaporation.

The vitriolization of the common pyrites used in these manufactures is a work of considerable time, more or less according to circumstances, but it is generally several months before a bed is entirely exhausted. Vitriol is however also made in several places from vitriolic peat, and in this the process is much shorter. A large manufactory of vitriol from this source is carried on near Beauvais in France, and thus described by M. Brisson.

The peat in the neighbourhood is of two kinds, the common combustible peat and the vitriolic. The former is, as in other countries, light, spongy, and full of visible remains of leaves, stalks, and vegetable fibres. The vitriolic on the other hand is easily distinguished by being heavier, harsher, and crumbly. The waters that run from it also deposit much ochre which readily detects the situation. The vitriolic peat is not found uniformly in any relative situation with the other species, but at different depths from the surface, to about ten feet.

This peat is hardly exposed to the air before it opens of itself, and becomes very dry and harsh, and soon heats even in small masses. To render the vitriolization more uniform, and prevent the too

drying effect of the sun, the peat is laid in heaps, only three or four inches in thickness, under sheds thatched with straw, where they remain for a few days, after which they are ready for lixiviation. This is done by throwing the peat into large vats of masonry, and covering it with rain water, which flows through the heaps and is collected for the purpose, and also with some of the mother water of the former crystallization. It is then evaporated and crystallized in the method already described.

In some places, the pyrites requires roasting, before it can be decomposed by the action of the air. Thus, at Geyer, in Saxony, the pyrites, after being exposed for some time to the air, is soaked in water for twelve hours, then roasted as in the ordinary method of roasting ores, in a large bed upon faggots, on which about seventy or eighty quintals at a time, are heated red-hot, and in this state plunged again into water. This is repeated six times successively, with the same pyrites, by which the water becomes strongly impregnated with vitriol, and is afterwards evaporated and crystallized as usual.

A quantity of heat is always generated during the process of vitriolization, both in the first combination of iron with sulphur, and the subsequent oxygenation of the sulphur, and consequent conversion into sulphuric acid, which enables it to dissolve the iron, and form the sulphat required.

The degree of the heat produced, and the quantity of moisture which the pyrites receives (by rain or other sources) are the circumstances that principally regulate the production of vitriol, both as to the quantity and time of its production. Too much heat actually kindles the mass; the remaining sulphur takes fire, and an immense quantity of sulphureous acid vapour is given off to a great distance around. Where this takes place, little or no vitriol is produced; for most of the sulphur and acid already formed is dissipated, and also the iron becomes too much oxydated to yield the crystallizable salt. Hence, it is dangerous and prejudicial to make too large heaps of pyrites, or to put it up into stacks, however preserved from the weather. Some moisture is also necessary to vitriolization; but too much of it keeps the pyrites too cold, and the process is languid. The iron added during the boiling is certainly useful, both as saturating the acid and increasing thereby the yield of the salt, and also as precipitating by its superior affinity, any copper which may arise from the admixture of copper pyrites, and also undergo vitriolization. In some manufactures, however, the admixture of a small portion of sulphat of copper, is even an advantage, as in the dyeing of hats.

Since the method of preparing the sulphuric acid from sulphur and nitre, has been universally adopted, a part of the use of vitriol of iron (namely for the production of sulphuric acid) has passed away; but it is still employed largely in the preparation of nitric acid in many places, besides its extensive use in dyeing.

Sulphat of iron is also made even in the large way, by the direct combination of iron and sulphuric acid, which is found to answer on the whole in point of cheapness, as a purer salt is obtained, and at an incomparably shorter time. Most of the salt of this kind used in medicine, is prepared in this way.

Copperas has been manufactured in this country from iron pyrites; and, during the war of '76, it was made in abundance near Lancaster, in Pennsylvania.

The green sulphat of iron, according to Kirwan, contains in 100 parts, 28 of black or sub-oxyd of iron (at 27 in 100 of oxygenation) 26 of real sulphuric acid, and 46 of water, of which he estimates 38 to be water of crystallization, and the remaining 8 to be water of composition.

Green vitriol when heated, melts in its own water of crystallization. When all this is driven off by a boiling heat, there remains a grey mass, commonly calcined vitriol. The salt has lost only water by this first process, as is proved by performing it in a retort, and collecting the liquor driven off by the heat. It was formerly called *dew of vitriol*, and several fanciful alchemical properties were ascribed to it. If the calcined vitriol be urged in a strong heat, and confined in a porcelain or luted glass retort, sulphureous acid gas, mixed with sulphuric acid, comes over and continues to do so for a considerable time, till the salt has been for some time, fully red-hot. What remains is a blood-red mass, consisting of a perfect oxyd of iron, with a small portion of still undecomposed sulphat of iron, which being now in the state of the red sulphat is deliquescent, and causes the mass to grow damp by exposure to air. This red mass is called *colcothar*, and is much used for polishing metals, glass, &c. but is previously washed in warm water, to extract every thing saline that remains. If colcothar is further urged with a very intense white heat, a large quantity of oxygen gas is given out, and an oxyd of iron is left, which is slightly magnetic, and therefore in the state of a sub-oxyd. Therefore, the decomposition of the sulphuric acid first affords a quan-

tity of oxygen to unite with the iron naturally in the state of sub-oxyd in the salt, and a very intense heat again drives off this additional oxygen, and leaves the iron nearly as at first. Along with the sulphureous gas that is given out so abundantly in distilling green vitriol, a quantity of a very strong smoking and peculiar sulphuric acid comes over, which concretes in the receiver in long striated rays or crystals. This acid from the place of its first production was called smoking vitriolic acid of Nordhausen. It is now found to be sulphuric acid saturated with sulphureous acid gas, to which it owes its concretibility.

The few observations to be made on the different alloys of iron, will all be described under the other metals respectively, except the manufacture of Tin-Plate, which may be here mentioned.

Tin-Plate or Tinned Iron (*Fer Blanc* of the French) holds an intermediate place between an alloy and a coating. It is made simply by immersing plates of iron into melted tin, whereby they not only become covered with a perfect coating of this metal, but a very intimate union of the two metals takes place, to a certain depth in the substance of the iron, which is seen by cutting it transversely, and when the tinning has been repeated two or three times, the whole plate is more or less alloyed, or as it were, soaked with the tin.

Tin-plate is manufactured in several countries, but no where to such perfection as in England, to judge by the quantity exported. The finest kind when highly polished, has a lustre and whiteness scarcely inferior to silver, and the peculiar excellence of the English plate, appears to be chiefly owing to the perfect smoothness given to the plate before tinning, and the great uniformity in the application of the metallic coating.

The general process is extremely simple, and is thus described by Mr. Donovan.

It is carried on near Caermarthen in South Wales, the centre of an immense and increasing manufacturing district, of many of the most important metals.

The iron ore employed in this manufactory, is the common kind of the country, intermixed with a large portion of the fine hæmatite from Ulverstone, in Lancashire, which gives a very fine metal. This too is smelted with charcoal, instead of coke, to produce a metal of the greatest purity and extensibility, and closeness of texture, which qualities are particularly required in this manufacture. The reduced ore is smelted in the usual manner, and cast into pigs, which are then wrought by the hammer into long flat bars, that are afterwards cut into pieces of about ten inches in length. These are then wrought into plates by being heated red-hot, and passed through a flatting-mill, which consists of two large cylinders of steel, case-hardened, and secured in a frame of iron. These are placed contiguous to each other, but with a certain interval of space, and revolve in a contrary direction; so that when one end of the bar is thrust in the space between the cylinders, the whole is drawn through and proportionably extended and flattened in the passage. The distance between the cylinders, which of course determines the thickness of the plate, is maintained and regulated by screws, which can be altered at pleasure. When the bar is thus made into a plate of twice the thickness of the ordinary plates, it is heated red-hot, cut in two by a pair of shears, and one piece folded exactly over the other, and both repassed repeatedly through the cylinders, till the folded plate has extended to the same length and breadth as the plate was before cutting. It is then clipped round the edges, and the two plates torn asunder (which requires some little force) after which they are each finished by passing through a finer rolling-press, so as to take away every crease or inequality in the plate, and those that are too rough to pass through this finer press, are thrown aside.

The plates are then steeped in a very weak acid liquor, and when taken out are scoured thoroughly with bran so as to be quite bright and polished to enable the tin to adhere. The tin is melted in deep rectangular crucibles, and kept fluid by a moderate charcoal fire beneath. To prevent its calcination a quantity of grease prepared from linseed-oil and suet is constantly kept floating on the surface of the tin and renewed as it evaporates off, which gives an excessively nauseous stench. The plate is then taken up by one corner by a pair of pincers and dipped vertically into the tin, and when withdrawn is found beautifully white and resplendent with the coating of this metal that adheres to it. This dipping is repeated three times for what is called single tin plate, and six times for the double plate. The plates are then only cleansed and sorted, and are fit for use.

Some further particulars may be added from other authorities.

In many manufactories the iron plates before tinning are cleansed by being immersed in large barrels full of a mixture of rye-flour and water, sometimes with verjuice which by fermentation has be-

come very acid. In Bohemia the plates remain three times twenty-four hours in tubs filled with this acescent mixture, in three different states, after which they are washed, scoured with sand and water, and kept under water till just before they are used, to avoid rusting again.

Attention is to be paid to the heat of the melted tin; if too hot, the plate comes out yellow. The plates are immersed quite wet into the melted tin, passing in their way through the melted suet which covers it. Just before dipping, some water is thrown on the melted suet, which causes a violent ebullition and makes the surface of the metal quite clean and bright. The plates when tinned are set up to drain, by which a number of drops of tin collect in small knobs at the lower part. These are taken off by a second immersion into a separate cauldron of tin, but only to the depth of a few inches, by which the drops of tin melt down and the whole tinning is made more uniform in thickness. They are then cleansed with a rag and saw-dust or bran. About 19½ pounds of tin are required for 300 plates, measuring 1 foot by 9 inches.

The manufacture of tin-plate in France appears to be conducted so nearly in the same manner as not to require a separate description.

In the manufactures of tin-plate on the continent a quantity of copper is always added to the tin, but in very small proportion. The exact quantity is regulated by slight circumstances, which only experience can teach. It appears to be in general from one-eightieth to one hundred and twentieth of the tin. The copper prevents the tin from adhering in too great a quantity to the iron, and causes the superfluous part to drain off more freely. Too much copper gives a dull yellow tint.

It appears that the method of flattening the bar into plate by cylinders is only adopted in this country, but in other places is done by the hammer.

The affinities of the oxyd of iron for the respective acids are in the following order: the gallic, oxalic, tartareous, sulphuric, muriatic, nitric, phosphoric, arsenic, fluoric, succinic, citric, acetic, boracic, prussic, and carbonic acids.

Method of connecting iron bars, and coating them with lead, so as to form solid pillars for light houses, on rocks covered at high water, without being subject to corrosion from the action of sea water. By Cap. Jos. Brodie, of the British Navy.—Trans. Soc. of Arts, vol. xxii.

In this method, four square rods of cast iron are composed of a number of pieces two feet long, and so rivetted together, that the ends of the component pieces are uniformly distributed, producing the effect of one bar of double the breadth and thickness of the smaller ones; a hollow tube of cast iron formed from a number of separate pieces, each about 10 inches long, which, when placed round the connected iron bars and screwed together, form a mould, into which melted lead is to be poured, to coat the rods or bars. By these means, the rods may, by small portions at a time, be completely covered with melted lead, so as to form a cylindrical pillar apparently of lead. The hollow cylinder is readily formed to any length required, by the junction of a number of semi-cylinders, fitting each other and rivetted together.

After a certain portion of the iron rods is coated with lead, the lower parts of the tube are taken off and placed higher up, so that a few tubes may answer the purpose of coating any length of the iron rods.

IRON, ores of American. See IRON.

IRON, sulphate of. See IRON.

IRON, gallate of. See INK and DYEING.

IRON, prussiate of. See COLOUR MAKING.

IRON, cast, crude, pig, &c. See IRON.

IRON, cold-short, hot-short, &c. See IRON.

IRON and carbon (steel.) See IRON.

IRON, hardening of. See IRON.

IRON and carbon (steel) blueing of.—The blueing of steel appears to affect its elasticity in a manner not easily explained. This operation consists in exposing steel, the surface of which has been first brightened, to the regulated heat of a plate of metal, or a charcoal fire, or the flame of a lamp, till the surface has acquired a blue colour. Now, if this blue colour be removed by grinding, the elasticity is completely destroyed, and may be restored by blueing the steel again. Rubbing with sand or emery-paper, glazing, or burnishing, equally impairs the elasticity in proportion as it destroys the blue coat. Saw-makers first harden their plates in the usual way, in which state they are brittle and warped: they then soften them by blazing, which consists in smearing the plate with oil or grease, and heating it till thick vapours are emitted, and burn off with a blaze; and after this they may be hammered flat: lastly, they blue them on a hot iron; which renders them stiff and elastic without altering their flatness.

The Damascus sword blades have long been celebrated for their excellence, but it is not known how they are made. Mr. Stoddart took six small bars of good mal-

leable iron, and the same number of sheer steel; laid them alternately on each other; welded them together; forged them into a stout flat plate, which was twisted spirally into a cylinder, hammered flat, and again welded; hammered this flat, doubled it throughout its length, inserted in the fold a slip of good steel to form the edge, and by another welding heat con solidated the whole into one mass. This being forged to a proper shape, cracked in different places on being cooled in water after heating: but Mr. Stoddart conceives, that by using more pieces, repeating the twisting, and not quenching in water, the process would succeed.

IRON, uses of, in dyeing.—Iron is one of the principal ingredients for dyeing black. The stuff is first prepared with a bath of galls and logwood, then with a similar bath to which verdegris is added, and lastly dyed in a similar bath with the addition of sulphat of iron. If it be wished, that the colour should be particularly fine, the stuff should previously be dyed of a deep blue: otherwise a brown may be first given with the green husks of walnuts. Silk however must not be previously blued with indigo, and sumach may be substituted instead of galls. Leather, prepared by tanning with oak bark, is blackened by a solution of sulphat of iron.

Cotton has a very strong affinity for oxide of iron, so that, if it be immersed in a solution of any salt of iron, it assumes a chamois colour, more or less deep according to the strength of the solution. The action of the air on the oxide of iron deepens the colour; and if the shade were at first deep, the texture of the stuff is liable to be corroded by it. To prevent this, the cotton should be immersed in the solution cold, carefully wrung, and immediately plunged into a ley of potash mixed with a solution of alum. After having lain in this four or five hours, it is to be wrung, washed, and dried.

Mr. Brewer, to give a nankin colour, prepares his cotton yarn by boiling it five hours in a mixture of water made grass green with sheep's dung and a solution of white soap; twice more, an hour each time, with half the quantity of soap; and a fourth time in a ley of pot or pearl ashes, one pound to twenty of yarn, another hour. He then passes it through iron liquor, to every gallon of which half a pound of red chalk, or ruddle, in powder is added; the liquor being poured off clear, after it has stood four hours to settle, and immerses it in an alkaline lixivium When of the proper colour, for which this operation may be repeated if necessary, he dries it, as after each of the former processes; and then puts it into a warm lixivium, in which it is brought to a scald. It is afterward to be soaked an hour in water made almost as sour as lemon juice with sulphuric acid, and then washed and wrung twice. Lastly, it is to be boiled slowly an hour in a solution of white soap, one pound to ten of yarn. See Dyeing.

IRON, ores of, American.—We have noticed the ores of this metal under the article iron. The American iron ores are the same as the European, if we except however some few species. The magnetic iron ores abound in different parts of the United States. Some specimens are considerably magnetic, and the ore generally yields a large per centum of iron. Magnetic iron ore is called also native magnet, or loadstone. The black ore, or steel grained iron ore, occurs in abundance in Pennsylvania, from which the Pennsylvania iron is obtained. The ochres are common, but are seldom used with a view of affording this metal. The yellow ochre is sometimes made into red ochre by calcination. See Colour Making.

Earthy, argillaceous, or bog ores of iron, occur in abundance in New Jersey, from which the Jersey iron is obtained. The colour of these ores is various, sometimes reddish, yellowish brown, and sometimes grey. The iridescent or crystallized iron ore, such as is obtained from the island of Elba, is not met with in this country. Hæmatites, an oxyd of iron, of different colours, is found in the United States, so is also the specular iron ore. Emery, which was formerly considered an iron ore, but now classed with corundom, is said to be found in Pennyslvania. The white or sparry iron ore, as well as iron pyrites, or sulphuret of iron, the grey iron, and plumbago, occur more or less in abundance in this country.

The blue combination of iron is found in the neighbourhood of bogs, principally in New Jersey. Bergman calls it native Prussian blue. Different opinions are entertained as to its formation, and chemical composition. See an Essay of the editor in Bruce's Mineralogical Journal. We intend, under the article Ore, to give a lengthy account of the different ores, and the modes of working them. It may be said with truth, that from all the ores of iron found in the United States, excellent iron is obtained.

Much interesting information on the subject of iron manufactures, as well as on the ores of this metal, may be found in the numbers of Cooper's Emporium. See also Bruce's Mineralogical Journal;

Seybert's Catalogue of some American Minerals in Coxe's Medical Museum; the papers of Maclure and Godon, in the Transactions of the American Philosophical Society, &c.

Important improvement in the working of iron.—In No. 1 of the new series of the Emporium of Arts and Sciences, edited by the learned Professor Cooper, it is announced from the Annales de Chemie, that *cast iron*, previously heated to a cherry red, may be cut like a piece of wood with a common saw.

As the truth of this discovery is of considerable moment to iron founders, and to all those who employ iron castings, Professor M'Neven tried this experiment a few days ago, and completely succeeded.

At the iron foundery of Messrs. Ward and Talman, the ingenious foreman of that establishment, Mr. Keenan, was directed to heat a *cast iron* bar, seven-eighths of an inch square, to a cherry red, in which state it was cut through with a common handsaw in one minute and a half. The saw was not the least injured by the process. The workmen who witnessed it, observed that it must succeed with still more facility, when a saw is used that is better adapted to the purpose; one having finer and closer teeth, and a perfectly straight edge. During the operation, very numerous and brilliant scintillations issued from the iron, as when it burns in oxygen gas.

New York Amer. Med. and Philos. Register for July 1813.

IRRIGATION. See AGRICULTURE.

ISINGLASS. See GELATIN.

IVORY BLACK. See COLOUR MAKING.

IVORY, silvering of. See SILVER.

IVORY, gilding of. See GILDING.

J.

JACK, in mechanics, a well known instrument for raising great weights of any kind, &c. See MECHANICS.

JAPANNING, is properly the art of varnishing and painting ornaments on wood, in the same manner as is done by the natives of Japan in the East Indies.

The substances which admit of being japanned are almost every kind that are dry and rigid, or not too flexible; as wood, metals, leather, and paper prepared.

Wood and metals do not require any other preparation, but to have their surfaces perfectly even and clean; but leather should be securely strained, either on frames or on boards; as its bending, or forming folds, would otherwise crack and force off the coats of varnish. Paper should be treated in the same manner, and have a previous strong coat of some kind of size; but it is rarely made the subject of japanning till it is converted into papier mache, or wrought by other means into such form, that its original state, particularly with respect to flexibility, is changed. One principal variation from the method formerly used in japanning is, the omitting any priming or undercoat, on the work to be japanned. In the older practice such a priming was always used; the use of which was to save in the quantity of varnish, by filling up the inequalities in the surface of the substance to be varnished. But there is a great inconvenience arising from the use of it, that the japan coats are constantly liable to be cracked, and peeled off, by any violence, and will not endure near so long as the articles which are japanned without any such priming.

The French still retain the use of this undercoat, and their japanned goods are upon that account less durable than those manufactured at Birmingham, where it is not used.

Of the nature of Japan Grounds.—When a priming is used, the work should first be prepared by being well smoothed with fish-skin or glass-paper, and being made thoroughly clean, should be brushed over once or twice with hot size, diluted with two-thirds water, if it is of the common strength. The priming should then be laid on as even as possible, and should be formed of a size, of a consistency between the common kind and glue, mixed with as much whiting as will give it a sufficient body of colour to hide the surface of whatever it is laid upon, but not more. This must be repeated till the inequalities are completely filled up, and then the work must be cleaned off with Dutch rushes, and polished with a wet rag.

When wood or leather is to be japanned, and no priming is used, the best preparation is to lay two or three coats of

coarse varnish, composed in the following manner.

Take of rectified spirits of wine one pint, and of coarse seed-lac and resin, each two ounces; dissolve the seed-lac and resin in the spirit, and then strain off the varnish.

This varnish, as well as all others formed of spirit of wine, must be laid on in a warm place; and if it can be conveniently managed, the piece of work to be varnished should be made warm likewise; and for the same reason, all dampness should be avoided; for either cold or moisture chills this kind of varnish, and prevents its taking proper hold of the substance on which it is laid.

When the work is so prepared, or by the priming with the compositon of size and whiting above described, the proper japan ground must be laid on, which is much the best formed of shell-lac varnish, and the colour desired, except white, which requires a peculiar treatment; and if brightness be wanted, then also other means must be pursued.

The colours used with the shell-lac varnish may be any pigments whatever, which give the tint of the ground desired.

As metals never require to be undercoated with whiting, they may be treated in the same manner as wood or leather.

White Japan Grounds.—The forming a ground perfectly white, and of the first degree of hardness, remains hitherto a desideratum in the art of japanning, as there are no substances which form a very hard varnish, but which have too much colour not to injure the whiteness, when laid on of a due thickness over the work.

The nearest approach, however, to a perfect white varnish, already known, is made by the following composition.

Take flake-white, or white lead, washed over and ground up with one-sixth of its weight of starch, and then dried; and temper it properly for spreading with mastich varnish.

Lay these on the body to be japanned, prepared either with or without the undercoat of whiting, in the manner as above ordered; and then varnish it over with five or six coats of the following varnish.

Provide any quantity of the best seed-lac, and pick out of it all the clearest and whitest grains, reserving the more coloured and fouler parts for the coarse varnishes, such as that used for priming or preparing wood or leather. Take of this picked lac two ounces, and of gum animi three ounces; and dissolve them, being previously reduced to a gross powder, in about a quart of spirits of wine, and strain off the clear varnish.

The seed-lac will give a slight tinge to this composition; but it cannot be omitted, where the varnish is wanted to be hard; though, when a softer will answer the end, the proportion may be diminished, and a little crude turpentine added to the gum animi to take off the brittleness.

A very good varnish, entirely free from all brittleness, may be formed by dissolving as much gum animi as the oil will take, in old nut or poppy oil; which must be made to boil gently when the gum is put into it. The ground of white colour itself may be laid on in this varnish, and then a coat or two of it may be put over the ground; but it must be well diluted with oil of turpentine when it is used. This, though free from brittleness, is nevertheless liable to suffer by being indented or bruised by any slight strokes; and it will not well bear any polish, but may be brought to a very smooth surface without, if it be judiciously managed in the laying it on. It is likewise somewhat tedious in drying, and will require some time where several coats are laid on; as the last ought not to contain much oil of turpentine.

Blue Japan Grounds.—Blue japan grounds may be formed of bright prussian-blue: or of verditer, glazed over by prussian-blue, or smalt. The colour may be best mixed with shell-lac varnish, and brought to a polishing state by five or six coats of varnish of seed-lac; but the varnish, nevertheless, will somewhat injure the colour, by giving to a true blue a cast of green, and fouling in some degree a warm blue by the yellow it contains; where, therefore, a bright blue is required, and a less degree of hardness can be dispensed with, the method before directed in the case of white grounds, must be pursued.

Red Japan Grounds.—For a scarlet japan ground, vermilion may be used; but the vermilion has a glaring effect, that renders it much less beautiful than the crimson produced by glazing it over with carmine or fine lake, or even with rose pink, which has a very good effect, used for this purpose. For a very bright crimson, nevertheless, instead of glazing with carmine, the Indian lake should be used, dissolved in the spirit of which the varnish is compounded, which it readily admits of when good; and in this case, instead of glazing with the shell-lac varnish, the upper or polishing coats need only be used, as they will equally receive and convey the tinge of the Indian lake, which may be actually dissolved by spirits of wine, and

this will be found a much cheaper method than the using carmine If, however, the highest degree of brightness is required, the white varnish must be used.

Yellow Japan Grounds.—For bright yellow grounds, king's yellow, or turpeth mineral, should be employed, either alone, or mixed with fine Dutch pink, and the effect may be still more heightened, by dissolving powdered turmeric root in the spirits of wine, of which the upper or polishing coast is made, which spirits of wine must be strained from off the dregs before the seed-lac be added to it, to form the varnish.

The seed-lac varnish is not equally injurious here, and with greens, as is the case of other colours; because, being only tinged with a reddish yellow, it is little more than an addition to the force of the colours.

Yellow grounds may by likewise formed of Dutch pink only, which, when good, will not be wanting in brightness, though extremely cheap.

Green Japan Grounds.—Green grounds may be produced by mixing king's yellow, and bright prussian-blue, or rather turpeth mineral and prussian-blue. And a cheap, but fouler kind by verdigris, with a little of the above mentioned yellows, or Dutch pink. But where a very bright green is wanted, the crystals of verdigris, called distilled verdigris, should be employed; and to heighten the effect, they should by laid on a ground of leaf-gold, which renders the colour extremely brilliant and pleasing.

Orange Japan Grounds.—Orange coloured japan grounds may be formed by mixing vermilion, or red lead with king's yellow, or Dutch pink, or the orange lake, which will make a brighter orange ground than can be produced by any mixture.

Purple Japan Grounds.—Purple japan grounds may be produced by the mixture of lake and prussian-blue; of a fouler kind, by vermilion and prussian-blue. They may be treated as the rest, with respect to the varnish.

Black Japan Grounds without Heat.—Black grounds may be formed by either ivory black, or lamp black; but the former is preferable where it is perfectly good. These may always be laid on with shell-lac varnish; and have their upper or polishing coasts of common seed-lac varnish, as the tinge or foulness of the varnish can here be no injury.

Common Black Japan Grounds on Iron or Copper, produced by means of Heat.—For forming the black japan grounds by means of heat, the piece of work to be japanned must be painted over with drying oil, and a little lamp black; and when it is of a moderate dryness, must be exposed to such a degree of heat, as will change the oil to black, without burning so as to destroy or weaken its tenacity. The stove should not be too hot when the work is put into it, nor the heat increased too fast, either of which errors would make it blister; but the slower the heat is augmented, and the longer it is continued, provided it be restrained within the due degree, the harder will be the coat of japan. This kind of varnish requires no polish, having received, when properly managed, a sufficient one from the heat.

The fine Tortoise-shell Japan Ground, produced by means of Heat.—The best kind of tortoise-shell ground produced by heat, is not less valuable for its great hardness, and enduring to be made hotter than boiling water without damage, than for its beautiful appearance. It is to be made by means of a varnish prepared in the following manner.

Take of good linseed-oil one gallon, and of umbel half a pound; boil them together till the oil become very brown and thick; strain it through a coarse cloth, and set it again to boil; in which state it must be continued till it acquire a pitchy consistence, when it will be fit for use.

Having thus prepared the varnish, clean well the iron or copper plate, or other pieces which are to be japanned, and then lay vermilion tempered with shell-lac varnish, or with drying oil diluted with oil of turpentine, very thinly, on the places intended to imitate the more transparent parts of the tortoise-shell. When the vermilion is dry, brush over the whole with the black varnish, tempered to a due consistence with oil of turpentine; and when it is set and firm, put the work into a stove, where it may undergo a very strong heat, and must be continued a considerable time; if even three weeks or a month, it will be the better.

This was given amongst other receipts by KUNCKEL; but appears to have been neglected till it was revived with great success in the Birmingham manufactures, where it was not only the ground of snuff-boxes, dressing-boxes, and other such lesser pieces; but of those beautiful tea waiters which have been so justly esteemed and admired in several parts of Europe, where they have been sent. This ground may be decorated with painting and gilding, in the same manner as any other varnished surface, which had best be done after the ground has been duly hardened by the hot stove; but it will be best to give a

second annealing with a more gentle heat, after it is finished.

Method of painting Japan Work.—Japan work ought properly to be painted with colours in varnish; though, for the greater dispatch, and in some very nice work in small, for the freer use of the pencil, the colours are sometimes tempered in oil; which should previously have a fourth part of its weight of gum animi dissolved in it; or in default of that, gum sandarach, or gum mastich. When the oil is thus used, it should be well diluted with oil of turpentine, that the colours may lay more evenly and thin; by which means, fewer of the polishing or upper coasts of varnish become necessary.

In some instances, water colours are laid on grounds of gold, in the manner of other paintings; and are best, when so used in their proper appearance, without any varnish over them; and they are also sometimes so managed as to have the effect of embossed work. The colours employed in this way, for painting, are best prepared by means of isinglass size, corrected by honey or sugar-candy. The body of which the embossed work is raised, need not, however, be tinged with the exterior colour, but may be best formed of very strong gum water, thickened to a proper consistence by bole armenian and whiting in equal parts; which being laid on the proper figure, and repaired when dry, may be then painted with the proper colours, tempered with the isinglass size, or, in the usual manner, with shell-lac varnish.

Manner of Varnishing Japan-Work.—The finishing of japan-work lies in the laying on, and polishing, the outer coats of varnish which are necessary, as well in the pieces that have only one sinple ground of colour, as with those that are painted. This is in general done best with common seed-lac varnish, except in the instances, and on those occasions, where we have already shewn other methods to be more expedient; and the same reasons which decide as to the fitness or impropriety of the varnishes, with respect to the colours of the ground, hold equally with regard to those of the painting. For where brightness is the most material point, and a tinge of yellow will injure it, seed-lac must give way to the whiter gums; but where hardness, and a greater tenacity, are most essential, it must be adhered to; and where both are so necessary, that it is proper one should give way to the other in a certain degree reciprocally, a mixed varnish must be adopted.

This mixed varnish, as we have already observed, should be made of the picked seed-lac. The common seed-lac varnish, which is the most useful preparation of the kind hitherto invented, may be thus made.

Take of seed-lac three ounces, and put it into water, to free it from the sticks and filth that are frequently intermixed with it; and which must be done by stirring it about, and then pouring off the water, and adding fresh quantities, in order to repeat the operation, till it be freed from all impurities, as it is very effectually done by this means. Dry it then, and powder it grossly, and put it, with a pint of rectified spirit of wine, into a bottle, of which it will not fill above two thirds. Shake the mixture well together, and place the bottle in a gentle heat, till the seed-lac appears to be dissolved; the shaking being in the mean time repeated as often as may be convenient; and then pour off all that can be obtained clear by this method, and strain the remainder through a coarse cloth. The varnish thus prepared, must be kept for use in a bottle well stopped.

When the spirit of wine is very strong, it will dissolve a greater proportion of the seed-lac; but this quantity will saturate the common, which is seldom of a strength sufficient to make varnishes in perfection. As the chilling, which is the most inconvenient accident attending varnishes of this kind, is prevented, or produced more frequently, according to the strength of the spirit; we shall therefore take this opportunity of shewing a method by which weaker rectified spirits may with great ease at any time be freed from the phlegm, and rendered of the first degree of strength.

Take a pint of the common rectified spirit of wine, and put it into a bottle, of which it will not fill above three parts; add to it half an ounce of pearl-ashes, salt of tartar, or any other alkaline salt, heated red hot, and powdered as well as it can be without much loss of its heat. Shake the mixture frequently for the space of half an hour; before which time, a great part of the phlegm will be separated from the spirit, and will appear, together with the undissolved part of the salts, in the bottom of the bottle. Let the spirit be poured off, or freed from the phlegm and the salts, by means of a tritorium, or separating funnel; and let half an ounce of the pearl-ashes, heated and powdered as before, be added to it, and the same treatment repeated. This may be done a third time, if the quantity of phlegm separated by the addition of the pearlashes appears considerable. An ounce of alum reduced to powder, and

made hot, but not burnt, must then be put into the spirit, and suffered to remain some hours, the bottle being frequently shaken; after which the spirit, being poured off from it, will be fit for use.

The addition of the alum is necessary to neutralize the remains of the alkaline salt, which would otherwise greatly deprave the spirit, with respect to varnishes and lacquer where vegetable colours are concerned, and must consequently render another distillation necessary.

The manner of using the seed-lac, or white varnish, is the same, except with regard to the substance used in polishing; which, where a pure white of a great clearness of other colours is in question, should be itself white; whereas the browner sorts of polishing-dust, as being cheaper, and doing their business with greater dispatch, may be used in other cases. The pieces of work to be varnished, should be placed near a fire, or in a room where there is a stove, and made perfectly dry; and then the varnish may be rubbed over them by the proper brushes made for that purpose, beginning in the middle, and passing the brush to one end, and then with another stroke from the middle, passing it to the other. But no part should be crossed, or twice passed over in forming one coat, where it can be possibly avoided. When one coat is dry, another must be laid over it; and this must be continued at least five or six times, or more, if, on trial, there be not thickness of varnish to bear the polish, without laying bare the painting or ground colour underneath.

When a sufficient number of coats is thus laid on, the work is fit to be polished; which must be done, in common cases, by rubbing it with a rag dipped in tripoli, or rotten-stone, finely powdered; but towards the end of the rubbing, a little oil of any kind should be used along with the powder; and when the work appears sufficiently bright and glossy, it should be well rubbed with the oil alone, to clean it from the powder, and give it a still brighter lustre.

In cases of white grounds, instead of tripoli, or rotten.stone, fine putty, or whiting, must be used.

JELLY. See Gelatin.

JET. See Coal.

JOINERS' GLUE. See Gelatin.

JOINING of broken ware. See Cement.

JEWS' PITCH. See Bitumen.

K.

KALI. See Alkali.

KANNEL COAL, or, Cannel coal. See Coal.

KAOLIN, the Chinese name of an earth, used as one of the two ingredients of the oriental porcelain. Some of this earth was brought from China, and examined by Reaumur. He found that it was infusible, and supposed it to be a talky earth; but Macquer supposed it to contain clay, because it forms a tenacious paste with the other ingredient called petuntse, which has no tenacity. Bomare found, that it was a compound of clay, calcareous earth, mica, and small quartz crystals. He says, that he has found a similar earth upon a stratum of granite, and conjectures that it may be a composed granite.

As porcelain is now manufactured in various parts of Europe, some mineralogists have applied the term kaolin to the porcelain clay. See Clay, Porcelain.

KARAT. The fineness of gold is commonly noted by karats. Pure gold being considered to be divided into twenty-four equal parts, or karats; it is then said to be twenty-four karats fine. If the quantity of pure gold in any mass be less than this, that quantity only is noted in expressing the fineness. Thus, for example, if two parts out of the twenty-four be copper or other base metal, the gold is said to be twenty-two karats fine. This is the standard of British coin. See Assay.

The karat is a real weight used by jewellers, divided by us into four grains: but these grains are less than the grains of troy weight; four grains troy being equal to five of these subdivisions of the karat, according to David Jefferys.

KEDRIA TERRESTRIS. Barbadoes tar. See Bitumen.

KEFFEKIL. The *meerchaum* of the Germans, *spuma maris*. A stone of a white or yellow colour, soapy feel, and moderate hardness, which increases in the fire. It is the substance of which the large Turkey pipes are made. It is found in Crim Tartary, in Canada, in Flanders, and elsewhere. The Tartars use it instead of soap, as do likewise the country people in the barony of Hierges, in Austrian Flanders. Wiegleb found it to con-

sist of equal parts of magnesia and silex, whence it seems to operate as a fullers-earth. See EARTH (FULLERS). What Wiegleb analysed, had been manufactured into a pipe. Klaproth analysed it in its crude state. A whitish variety, of the specific gravity of 1·6, afforded him from 100 parts, silex 50·5; magnesia 17·25; lime 0·5; water 25; carbonic acid 5. A gray sort gave silex 41; magnesia 18·25; lime 5; water and carbonic acid 39. In a third he found the proportion of silex much less, and of magnesia as much greater. He could not expel the whole of the carbonic acid in the humid way.

KELP. See SODA.

KERMES (*coccus ilicis*, Lin.) is an insect found in many parts of Asia, and the south of Europe. It was known to the ancients by the name of *coccum scarlatinum, coccus baphicus, coccus infectiorius, granum tinctorium.* That which came from Galatia and Armenia was preferred: but at present it is gathered chiefly in Languedoc, Spain, and Portugal.

The kermes lives on a small kind of oak (*quercus coccifera*, Linn.) The females grow big, and at length remain motionless; when they are nearly the size and shape of a pea, and of a reddish brown colour. On account of their figure, they were a long time taken for the seeds of the tree on which they live; whence they were called, grains of kermes. They also bore the name of vermillion.

If the living insect be bruised, it gives out a red colour Its smell is somewhat pleasant; its taste a little bitter, rough, and pungent. When dry it imparts this smell and taste to water, and also to alcohol, to both which it gives a deep red colour. This colour is retained by the extracts made from these infusions.

To dye spun worsted with kermes, it is first boiled half an hour in water with bran; then two hours, in a fresh bath, with one fifth of Roman alum, and one tenth of tartar, to which *sour water* is commonly added; after which it is taken out, tied up in a linen bag, and carried to a cool place, where it is left some days. To obtain a full colour, as much kermes as equals three fourths, or even the whole of the weight of the wool, is put into a warm bath, and the wool is put in at the first boiling. As cloth is more dense than wool, either spun or in the fleece, it requires one fourth less of the salts in the boiling, and of kermes in the bath. Less proportions of kermes will produce lighter and paler colours. If we want a succession of shades, we must, as usual, begin with the deepest.

Hellot directs a small handful of cot or refuse wool, to be thrown into the boiler in which the kermes is, and to let it boil a moment before the wool to be dyed is put in. This will absorb a kind of black dregs, and the wool afterwards dipped, will take a better colour. Before the wool that is just dyed is taken to the river, it may be dipped in a bath of water a little warm, in which a small quantity of soap has been dissolved. In this way the colour will acquire more brightness, though it will be rendered a little rosy, that is, will have a crimson cast.

By using kermes and tartar, without alum, and with as much solution of tin as is required for a scarlet with cochineal, Hellot obtained a very lively crimson colour in a single bath. Cloth steeped in a solution of sulphat of potash, took with kermes a pretty fine and permanent agate gray: in a solution of sulphat of iron and tartar a fine gray: in a solution of tartar and sulphat of copper, an orange colour: and the same with nitrat of copper. Solution of bismuth, added drop by drop to a kermes bath, produced a violet. All acids convert it to a cinnamon colour, which inclines more or less to red, according as the acids are weak, and their quantity small. Alkalis render its colour dull and rosy.

The colour that kermes imparts to wool has much less bloom than the scarlet made with cochineal; whence the latter has generally been preferred, since the art of heightening its colour by means of solution of tin has been known.—*Berthollet.*

Formerly it was used in medicine as a cordial and mild astringent, and gave its name to a confection.

KERSEY, a kind of coarse cloth. See manufacture of CLOTH.

KILKENNY COAL. See COAL.

KILLAS. This stone is chiefly found in Cornwall; its colour is pale gray, or greenish gray; its texture either lamellar or coarsely granular: the lamellar is softer and less martial than the roof schistus: its specific gravity from 2·63 to 2·666.

Kirwan found a hundred grains of the lamellar sort to contain about 60 of silex, 25 of alumine, 9 of magnesia, and 6 of iron. The greenish sort contains more iron, and gives a greenish colour to the nitric acids.

KILN. The term kiln either implies a stove used in various manufactures, or a building for the admission of heat, in order to dry or burn certain substances. Thus we have the lime kiln, malt kiln, &c. which are too well known to require description. In the 5th volume of the Repertory of Arts, may be seen a description of a malt kiln, upon an extensive scale, the

invention of Mr. J. Pepper, of Great Britain.

KINGDOMS. Naturalists and chemists divide all natural bodies into three great classes, called kingdoms; namely, the mineral, the vegetable, and the animal kingdoms. The utility of these divisions appears to be, in a great measure, confined to the natural history of the various subjects examined by the chemist. The distinctive criteria of their respective principles are difficult, and perhaps impossible to be ascertained, excepting in bodies of no great simplicity; for none of the principles of organized bodies exhibit their peculiar characters when resolved by putrefaction or otherwise, into their simplest parts.

KING'S YELLOW. See Colour-Making.

KITCHEN, an apartment for the dressing of provisions. Considerable pains has been taken by our countryman, count Rumford, in the arrangement of the different culinary apparatus, in order to economize fuel in the construction of furnaces, kettles, &c. Several patents have been granted for improved *kitchen-range*, or stoves. The *ships kitchen*, invented by Mr. Brodie, includes a stove, hearth, smoke jack, and iron boilers. On the subject of count Rumford's improvements, we would refer the reader to his Essays, Economical and Philosophical.

KITCHEN GARDEN.—Under this head we shall treat of those subjects, which it was our original intention to have arranged under the title Horticulture.

This mode we have been induced to adopt from the nature of our work, the limits of which are too confined to warrant such a dissertation as would have embraced every branch of Horticulture. That article, if fully treated, would form a volume, and consequently occupy too much space, particularly when it is considered that so large a part of it is devoted to ornamental gardening.

Usefulness being the primary object, a concise treatise on the laying out of a Kitchen Garden, with an arrangement of the names and sorts of plants, and the modes of culture, is believed to be more appropriate and better adapted to our general design.

A kitchen garden should be laid out in different methods, according to the differences in the circumstances of the ground. It is sometimes so managed, as to constitute a part of, or communicate with the pleasure-ground; but where there is sufficient extent of land, it is better to be distinct, or detached from it, and in every case as much concealed from the house as possible. The most convenient distribution is at some distance behind it; but on the sides may answer very well, especially when not too contiguous, or so situated as to interrupt any particular prospect or view of the adjacent country.

Exposure.—With regard to the nature of the situation most proper for this purpose, it should, when convenient, be where there is a gentle declination towards the south, or south-east, in order that it may have the full advantage of the morning sun.

The nature of the exposure of a garden is a matter of considerable importance, as not being capable of change like those of shelter, soil &c. It has been observed, by a late writer on "Country Residences," that the best exposure for a garden is that of the south-east, but that in an extensive and complete garden, it is desirable that part of it should have a northern aspect, in order that late crops may be raised with advantage. And this, it is supposed, may often be attained, either by fixing upon both sides of a gentle swell, or eminence, or on the two opposite sides of a hollow or depression. Should such a hollow wind in any considerable degree, every sort of exposure would at once be had without difficulty, and mostly in combination with shelter and proper soil.

Situation.—This should be relative to the nature of the rest of the place, and the convenience of water. It should be somewhat contiguous to the necessary offices, stables, &c. and at no great distance from the farm, being concealed as much as possible from general view, and so contrived, as to interfere but little with picturesque improvements. It should be so near a supply of water as to have it in abundance for the common purposes of watering during the whole of the summer months. And it may be used in other ways with advantage, in particular situations and circumstances. It is a common but dangerous error to form gardens in too low situations, in order that they may have the benefit of natural shelter, as they are very liable to the effects of hoar frosts, blights, and mildews. Mr. Forsyth remarks, in his "Treatise on the Culture and Management of Fruit Trees," that if a garden "be situated in a bottom, the wind will have the less effect upon it; but then the damps and fogs will be very prejudicial to the fruit and other crops;" and that when "situated too high, although it will, in a great measure, be free from damps and fogs, it will be exposed to the fury of the winds, to the great hurt

of the trees, by breaking their branches, and blowing down their blossoms and fruit."

Shelter.—A garden should, in this writer's opinion, "be well sheltered from the north and east to prevent the blighting winds from affecting the trees, and also from the westerly winds, which are very hurtful in the spring or summer months." Where it is not "naturally sheltered with gentle rising hills, which are the best shelter of any, plantations of forest-trees should," he thinks, "be made at proper distances, so as not to shade it." These, he supposes, will be found the best substitute, but at the same time the sun and air should be freely admitted. On this account it is supposed that "a place surrounded by woods is a very improper situation for a garden or orchard, as a foul stagnant air is very hurtful to vegetation." It is likewise added that "blights are much more frequent in such situations than in those that are more open and exposed." In these sheltering plantations, it is well advised that fruit-trees should be intermixed with those of the forest kind, which, besides being advantageous in the way of affording shelter, ornament, and fruit, become nurseries for raising forest-trees. But where the situations will not admit of this, he suggests the propriety of planting some cross rows of fruit-trees in the garden, at the distances of about forty or seventy yards from each other, more or less, according to the extent: where the length is considerable, one row may be sufficient on each side: but in short cross rows, two on each side the walks or paths. In this intention the trees should be planted opposite one another, but in such a manner that those in one row may be opposite to the middle parts of the open spaces in the others. In this method, besides the ornamental effect that is produced, the force of violent winds is broken, and much damage to other trees prevented.

In this view, the best sort of trees, according to the same writer, is that of dwarfs, with stems about two feet high, which may readily be provided by removing the lower branches.

The author of the Treatise on Country Residences advises, "that the planting should be performed on all sides of the garden, the distance being proportioned according to the particular circumstances of the case. But when the garden is upon the perfect flat, the nearest forest trees should not, in common, be within less than one hundred feet of the outer fruit wall, nor on the south side within less than one hundred and twenty, or thirty feet of it; where however it is upon a rising bank, they may sometimes be admitted to come as near as fifty or sixty feet. It is likewise in most cases a good way to form a deep sunk fence between such trees and the garden ground, especially when they are of the fir tribe, in order to prevent the roots from running too much in the surface mould of the garden."

Soil.—In fixing upon ground for a garden, it is likewise a point of much importance to have the natural soil of a good quality, being sufficiently dry, mellow, and capable of being easily wrought in al seasons, as well as of a good depth, as from a foot and a half to three feet. And if the surface be uneven, it will be the better, as there will be a greater variety in the quality, and of course will be more fully adapted to the culture of different crops. The most proper sort of soil for this purpose is that of the rich, friable, loamy kind, and the worst those of the very light, sandy, and stiff clayey descriptions. But the properties of soils may be much improved in most cases by a judicious application of different sorts of materials in the way of manure.

Some think a medium loam the most proper, as being capable of being made of different degrees of lightness in different parts, by the addition of sand and other similar materials, so as to suit different sorts of vegetables; and in others of various degrees of tenacity and heaviness, by the use of clay or other cohesive substances.

Where the under soil is of the retentive kind, great care should be taken to have it well drained, as unless this be effectually accomplished, healthy vegetables or trees can seldom be produced. See Agriculture.

In cases where fruit-trees, especially those of the finer sorts, as well as apple and pear kinds are to be planted, a greater depth of good soil, as well as a greater degree of dryness, is necessary in general than that mentioned above.

Form.—There are very different opinions in respect to the most proper and advantageous forms for this sort of culture; but though much must depend on the nature of the situation, where the spade is to be made use of in performing the work, the square shape, or that which approaches nearest to it, is probably the most convenient. In other cases, where the principal part of the work is, from the difficulty of procuring labourers, and the increasing expence of them, to be executed by

the plough, the oblong and circular forms may be the most suitable, as they may be wrought with greater facility and convenience. The shape of the garden is usually decided by the walls; but that which is most adapted to the general purposes of cultivation is, in the opinion of the above writer, that of a parallelogram; though were the chief object the production of wall-fruit, the oval form with its long diameter from east to west would be better, as containing the smallest quantity of wall hid from the sun, and a large portion of it constantly exposed to the south. But as all forms, except those of the square kind, derange the regulation of the quarters, and are consequently troublesome in digging and cropping; they are in general properly discarded, except in some flower-gardens, where fruits are raised on the walls.

Size—The size of kitchen-gardens, should always be fully sufficient for the extent of the family, varying from half an acre to four, five, or more, within the fence. The first quantity, where there are wall and espalier trees, will furnish sufficient employment for one man, and afford due supplies of vegetables and fruit for families, consisting of a dozen or more persons. But much in these respects depends upon proper care and management. The nature of the soil should also be taken into the account in determining this point.

Inclosing—The methods of inclosing that are pursued in these cases, vary according to the facility of procuring materials on the particular spots. Some advise the boundary fence to be a sunk one, with a hedge or low wall; but others think the best mode of inclosing garden-ground is by means of brick walls, where that sort of material can be easily procured, and expence is not an object. But oak paling fences answer the purpose very well. These fences, whether made of brick or wood, should be eight, ten, or twelve feet in height. Where the extent of walling is sufficient, Mr. Forsyth thinks ten feet walls better than such as are higher, as being more convenient for various purposes. He also advises, that they should have borders or slips on the outside of them, of from forty to sixty feet or more in breadth, where the ground can be spared, which should likewise be inclosed by an oak paling, six or eight feet in height, having a *chevaux de frise* at the top to strengthen the fence, and render the garden more secure. The latter may be conveniently formed, by planting a piece of wood four inches in breadth, and an inch and a quarter in thickness, into the shape of the roof of a low pitched house on the upper side, then drawing a line on each side from end to end, at the distance of about an inch and quarter from the upper edge, driving twelve-penny nails through them in regular rows, at the distance of four inches from each other, so as to come out near the upper edge of the contrary side: each being opposite the middle of the space between two nails on the other side. The nail heads should be sunk, and strips of wood nailed over them, tenter-hooks being driven in between the nail points, and the whole nailed fast to the outside top of the fence; continuing pieces in this way till the whole is completed and rendered secure. It is supposed that by means of these inclosed borders or slips on the outside of the garden walls, there will be plenty of ground for gooseberries, currants, and strawberries, and both sides of the walls may be planted with trees, by which there will be a considerable increase of wall-fruit. And where there are parts of such slips lying near to the stables, sufficiently sheltered and exposed to the sun, they may be converted to the purposes of a forcing-ground for raising melons, cucumbers, and other similar kinds of fruit.

The advantages of this are, that there will be no litter carried within the walls, to dirty the walks; the beds will be concealed from the sight, and much time and labour saved in carting and wheeling the dung and other matters.

Where there are not these sorts of slips, the forcing-grounds for melons, cucumbers, &c. should be made in situations that are warm, and open to the influence of the sun, being well inclosed, and as contiguous to the stable as the nature of the situation will admit. It is added, that the great objection to having slips or borders on the outsides of the walls of gardens, is that of the vast expence of erecting two fences, where one is capable of answering the purpose, and by proper attention in the distribution of the internal parts, with perhaps nearly equal advantage.

The author of the work on "Country Residences," after observing that the northern side of such garden-strips should be reserved for common crops, and the southern for early ones, suggests that a shrubbery may, in some instances, be introduced with propriety, in a part of the space towards the plantation, so as to range in order with mixed plants, from the humblest shrub in the edge of the walk, to the highest forest trees. In this way

complete shelter may be afforded, and at the same time an agreeable effect produced at most periods of the year. But, in many cases, its place may be supplied simply by a single holly hedge, placed on the top of the sunk fence, by which means a large portion of ground may be applied to the raising of culinary vegetables, and the character of utility be more fully preserved. It occasionally happens, from the declination of the ground in a southerly direction, that the uniformity of such "outer inclosure can be broken, and a large bay or recess be made in the wood, either to contain all the hot-houses, hot-beds, &c." or the latter only; which is always a great advantage.

Subdivision—In the distribution of the quarters or parts of the garden, attention should be had to the nature, form, and extent of the ground, so as that they may be laid out in the best manner, in respect to the convenience of managing them, exposure, and size; but they should never be made too small, as there will be much loss of ground by the walks, which are essentially necessary in their cultivation. With regard to their form, it may vary according to circumstances, or the taste of the proprietor; but the most convenient and economical one, in respect to ground, is the square, where the garden has been laid out in that manner. It is usual to have borders round the whole of the inclosing fences, whether they be constructed of brick, stone, or timber; and where there are cross walls, they are generally introduced on the sides of them. The breadths of these should be proportioned to the heights of the walls or palings, and the extent of the garden, as from six, to eight, ten, and twenty feet, especially those which have a southern aspect, and are intended for the reception of fruit-trees, as their roots will have more room to extend themselves and procure due nourishment. Besides, wide borders are the most advantageous and economical in the culture of different vegetable crops.

Where the gardens are large, other borders may be carried along on the sides of the walks, between them and the espalier or standard fruit-trees; but in other cases this is inconvenient, as taking up too much of the quarters. These should not exceed six or eight feet in breadth.

With some it is the practice to have the edges of the borders made firm and even, and planted with dwarf box, or some other plant made use of for the purpose; but as these sorts of edgings are very liable to be destroyed in different places by wheeling over them, and by that means become unsightly, it is probably a better method to only have the edges of the border made up firm and even, close to the gravel of the walks.

Walks.—In common there should be a walk introduced on the sides of the borders all round, and likewise in the middle where the ground is of considerable extent. Cross walks are also necessary where the garden has a great length. But as walks take up much ground, there should be as few as possible. Those on the sides of the borders need not have more breadth than from four to six feet; but the middle one should be seven feet wide, in order that a cart may be admitted when necessary.

It is also necessary to have walks about two feet or two feet and a half wide, and the same distance from the walls, where there are wall-trees, for the convenience of pruning, training, and nailing, as well as that of gathering the fruit, and admitting a barrow or garden engine for watering them.

And besides these permanent walks, when the gardens are of much extent, trodden path-walks will be requisite in different parts, for the convenience of cultivation, and as divisions between the crops of different kinds.

All the first sorts of walks should be laid out in a regular manner, and be firmly made up with brick rubbish, stone-masons' chippings, or some other coarse material; and neatly gravelled over. For this last purpose binding sand answers extremely well, also good clean sifted road drift, as they may be readily kept clean by the hoe and rake; but sea-coal ashes are preferred by some, as being still more dry and firm, more easily kept in order, and cleaner to walk upon in thaws, as well as useful, while new and rough, in preventing slugs from travelling over them from the different quarters of the ground.

The narrow walks on the back sides of the borders near the fruit-trees, need not be laid with any sort of coarse rubbish, being merely covered over to the depth of a few inches with sand or sea-coal ashes, as by this means the ground may be occasionally dug up, and the path relaid.

Whatever sort of material is made use of in forming the walks, it should be spread in a neat even manner, so as to leave them in a regular moderate convex or rounded form, by which the water will be readily carried off to the sides, and the walks kept perfectly dry. After the surface material has been thus applied, and evenly raked over, it should be firm-

ly rolled down by a heavy iron roller, and occasionally repeated after being well moistened with rain.

Sometimes walks are laid with turf or sward, but this is a very improper material, as being troublesome to keep in order, and soon rendered disagreeable to the sight, by being wheeled and trampled upon in the work of the garden.

Walls.—In building the walls of kitchen-gardens, when the height is considerable, the foundation should be from two to two bricks and a half in thickness, and the off-set not more than one brick above the height of the level of the border, being then brought to a brick and a half in thickness; where they are extensive, they should be strengthened by piers at the distance of from forty to sixty feet, according to their height. The projection of these piers should not be more than about half a brick before the surface of the wall. Walls for fruit-trees should always, if possible, be built with brick, as stone is found not by any means so favourable to the maturation of the fruit, and far more inconvenient in the nailing of the trees.

Where situations cannot be provided with convenience without the walls of the garden for the whole of the forcing apparatus, the pits and hot-beds may be placed in sunk areas in the quarters of the gardens as near as convenient to the hot-houses.

Copings.—Some advise projecting copings of stone or wood to be fixed upon the tops of the walls, and the author of the "Philosophy of Gardening" conceives that they may be of great utility in the early vernal months in preventing the tender young shoots of fruit-trees from being destroyed by frost, as, from their being less imbued with the night-dews in consequence of them, they will be less exposed to danger from that cause; it being well ascertained that the fine shoots of vegetables are most exposed to the destruction of frost when in a moist state.

But Mr. Forsyth does not however approve of such fixed copings, especially when they project so far as is usually the case; moveable wooden ones fastened by iron hooks to pieces of wood built into the tops of the walls being in his opinion preferable. Besides, they are useful to fix nettings, &c. to, in the early spring, for protecting the trees. When fixed copings are adopted, they should not, he thinks, extend above an inch on each side of the wall, as the slight projection will be sufficient to preserve it, and at the same time not prevent the dews and rains from falling upon the upper parts of the trees, by which they are greatly benefited. Copings are sometimes formed of a sort of brick made convex on the side which is upwards; but these are expensive.

Mr. Forsyth suggests that common copings should have a little slope given them "towards the north or east, according to the aspect of the wall," by which the wet from the south and west sides may be taken away, and the danger of the early blossoms and fruit being injured on the south and west walls in cold nights be avoided.

Drains.—Where the soil of a garden is naturally of a stiff quality, and retentive of moisture, proper under-draining will be essentially necessary in order to the production of good well tasted fruit, as well as fine culinary vegetables. In these cases the main or leading drains should be made under the walks, and those from the quarters be formed to communicate with, and empty themselves into them. They should be constructed of bricks, either common or such as are formed for the purpose, and be laid in such directions as are the best adapted to the removal of the injurious wetness, and always of such depths as to prevent their being injured by the spade in working the ground. By this means the soil will be kept in a suitable state for the growth of the plants, and the walks preserved in a fine state of dryness, so as to be sufficiently firm for carting or wheeling upon, even in wet seasons.

Where the ground destined for the purpose of forcing is on a level considerably lower than that of the garden, the water from the latter may be made to supply the former, by having the main leading drain terminating in a tank, pond, or cistern constructed in it for the purpose, which in many situations may be extremely convenient and useful.

In many cases, and especially where the garden grounds are of a dry quality, it is of vast advantage to have them situated contiguous to rivers, brooks, or large basons of water, from which they can be supplied by means of drains, pipes, or other contrivances, in the most hot and dry seasons of the year.

But where no supplies of water can be provided and brought to the garden in these ways, Mr. Forsyth suggests that where they lie on the sides of public or other roads, and the level of the ground is suitable, hollow drains should be formed in the most convenient parts, to receive the water that washes them in rainy seasons, and convey it to large ponds or other

places made for its reception in the highest part of the garden ground that will admit of it, from which it may be dispersed to the different quarters that will allow of it by pipes, with cocks fixed at different places for turning it on, as may be necessary. Or, by having suitable channels cut, it may be turned upon different parts, as in the practice of watering meadow land; which, where the roads are repaired with calcareous materials, or there is much vegetable matter washed down them, may be highly beneficial in the way of manure. A proper ready exit for the superabundant water must always be provided in these cases, to prevent stagnation. And where the ground has been much enriched by stable manure, the practice should be cautiously adopted, as more fertility may be conveyed away in the state of solution than is brought by the water. The most convenient time for turning on water is generally during the night, which in dry seasons, is the most advantageous to the plants or crops that are upon the ground.

The expence in pipes, drains, channels, and other apparatus for these purposes, will be considerable at first; but the saving in labour and time, in pumping and carrying water, it is conceived, will soon repay it. Where water is under the necessity of being pumped up from deep wells, large basons or reservoirs should be provided, in which it should remain some time exposed to the influence of the atmosphere, before it is made use of in the above or any other way in gardens.

Where garden grounds are of a wet oozing quality, Mr. Forsyth recommends basons to be formed in the most convenient parts of them, for the reception of the water that proceeds from the drains, and which falls in rain on the walks and paths, as well as other parts.

Forming new Gardens—In forming new kitchen garden grounds, where the soil is of a strong, stiff, heavy quality, they should be ploughed or trenched over three or four times, being exposed to the effects of frost, in pretty high ridges, for a winter, in order to bring them into a proper condition before the crops are put in. A crop of potatoes or beans, also assists greatly in bringing them into a proper state of pulverization for being planted upon with culinary vegetables.

When the land is become sufficiently broken down and reduced, the wall and other trees, as well as different sorts of vegetable crops, may be put in. Some, however, put the fruit-trees in before this has been accomplished; but it is not a good practice, as they are liable to be injured by the digging which afterwards becomes necessary in preparing the soil in a proper manner.

In planting wall-trees, they should be set at different distances, according to the kinds: those of the peach, nectarine, apricot, plum, and cherry descriptions, at fifteen, eighteen, or more feet, and for figs and pears, twenty are seldom too much, suitable aspects being chosen according to the kinds. Between their wall-fruit-trees, some at first introduce half or full standards, that the walls may at once be covered, removing them afterwards. But this is a method that should never be attempted where it can be avoided, as being very disadvantageous. Trees of the espalier kind, are likewise frequently introduced in ranges round the main quarters at the distance of about six feet from the side of the walk, and from fifteen to twenty in the rows, according to the sorts that are made use of. Within these ranges of espalier trees, good standards of tall growth are occasionally introduced at the distance of thirty, forty, or more feet in each direction. Where there are orchards this should, however, always be avoided as much as possible.

Fruit-trees of the small shrubby kinds, such as goose-berries, currants, raspberries, &c. where there are not out-slips, are frequently introduced on the sides of the quarters, and as divisions to them when large, at the distance of eight or nine feet from each other. When planted in this way, they should be trained in the fan form. But it is better, where it can be done, to have them in separate plantations, especially the first sort.

Cropping—In respect to the distribution of the vegetable crops, it must be regulated by the nature of the situation, their particular kinds, as well as the taste and experience of the gardener. On the narrow borders under the wall-trees, various sorts of small crops may be grown, both of the early and late kinds, according to the difference of the aspects; but all the deep rooting sorts should be avoided, such as cabbages, cauliflowers, beans, pease, except those of the frame kind, as being injurious to the trees by the shade which they cause, as well as by depriving them of due nourishment.

But the large parts of the borders next the walks, are proper for raising all sorts of the more early crops, such as those of the radish, lettuce, spinach, carrots, French beans, sallad herbs, and all the dwarf pea kinds that are cultivated in wide rows; those which have a southern

aspect for the earliest crops; and the eastern and western ones, for succession crops of the several kinds; and the northern ones, as being more cool, for raising and pricking out many sorts of small plants, slips, and cuttings in the summer season, when the other parts are apt to be too dry, and too much exposed to the heat of the sun.

All such borders as are next to the ranges of espalier trees are well suited to the different low growing crops, such as lettuce, spinach, endive, straw-berries, &c. and for bricking out upon, at different seasons, many sorts of plants to be afterwards transplanted into different situations, in order to complete their growth.

But the quarters or large divisions should always be destined for the reception of the large principal crops, such as those of the onion, leek, carrot, parsnip, turnip, beet, potatoe, cabbage, cauliflower, brocoli, colewort, kale, pea, bean, scarlet-bean, celery, artichoke, asparagus, and other similar kinds.

In every department the greatest attention should be paid to the keeping of the different parts fully cropped, as well as to neatness and regular order; and as the crops are removed from the ground in the autumn, it is often of great advantage to have it ridged up for the winter in a regular manner.

Where the garden has been thus laid out, planted, and finished, Mr. Forsyth has found much advantage from having a plan of it, with the names of the different trees introduced in their proper places. By this means the memory is greatly assisted, especially in extensive grounds, and the various operations performed with more regularity and exactness.

Mr. London advises that in complete residences the kitchen garden should be laid out at first, and directed afterwards solely in the view of cultivating and producing culinary fruits and vegetables. Little or nothing of the ornamental kind should be introduced, but utility every where predominate. Even the edgings of the walks should be planted in most cases with useful plants, such as straw-berries, parsley, &c.

Preparation of the Soil—The proper performance of this depends upon a variety of circumstances, such as the nature of the land, the kind of crop that is to be cultivated, and the season at which it is put in. After the primary operations of cleaning and draining have been executed, it is generally necessary to break down and reduce the earth into a fine state of mould by common or trench-digging; and the exposure of a large surface to the action and influence of frost, or the effects of heat and moisture in alternation, as in ridging and summer-trenching.

There are other modes that contribute to the production of the same effect, such as the growth of particular sorts of crops, as celery, and those of the carrot, parsnip, beet, and others of the tap-rooted kind: and the application of strong hand-hoes to the superficial parts at proper periods, as when the soil has a disposition to fall down in a powdery condition. This last method, will likewise, at the same time, extirpate and destroy a number of weeds; but the necessity of this should be constantly well guarded against, by suffering none to run to seed in the garden.

Considerable advantage may also be gained in the view of rendering garden ground mellow, by the proper application of suitable manure. In this view the manure should not have advanced too far in the state of decomposition. Composts and very rotten manures produce but a trifling effect in this way, though highly beneficial in various other respects. It seems not improbable but that, in hot seasons, where the soil is inclined to be heavy and of course lumpy, benefit might be derived from the use of a small roller upon the surface.

How far advantage is capable of being derived from the *resting* of the soil in this sort of culture, is perhaps not yet fully ascertained; but certain kinds of garden crops are commonly supposed to grow better on new land than such as have been long under cultivation, as those of the onion, the carrot, the turnip and the potatoe kinds. Therefore, different methods of effecting this purpose have been proposed, such as laying down portions of garden-ground annually with grain and grass seeds, and breaking others up. This can, however, be only practised in large gardens, either with convenience or the prospect of success; and in all cases must be employed with much caution.

Another mode is by trenching to different depths alternately, as three and two spits, so as to have new or fresh surfaces from the top, middle, and bottom, cropping each three years, and letting the future surfaces rest six. This practice has been recommended by Mr. Walter Nicol. But it can only be had recourse to in particular instances, as few gardens admit of three spits' depth of good soil. Besides, the expence of performing it affords a considerable objection.

Succession of Crops—This is a matter of considerable importance in culinary gardening, as the growth of good and healthy vegetables, and the keeping of the soil in a proper state of heat, in a great measure, depends upon it. The main principle on which it proceeds, is that of never growing what are termed exhausting crops in succession; or letting two or three of the same nature or sort, follow each other. It is well known to horticulturists, that under such circumstances, they constantly become deteriorated in quality, and greatly lessened in the quantity of produce. The closeness of shade afforded by the plants, is also another principle that should be carefully attended to in managing this business. In this practice it has been suggested by Mr. London, that "the vegetables cultivated should be divided into classes according to their respective natures, modes of culture, and duration." It is conceived that in respect to *natures*, they may be divided into, 1st. Such as have ramose roots, as the cabbage, cauliflower, brocoli, &c. 2d. Such as have fusiform roots, as the carrot, beet, parsnip, &c. 3d. Such as are squamose, as the onion, leek, eschalot, &c. 4th. Such as are fibrous, as the lettuce, endive, &c. 5th. Such as are tuberose, as the potatoe, Jerusalem artichoke, &c. They are supposed capable of further division, "into such as partake of two of these divisions, as the fusiform and fibrous, exemplified in the bean, pea, kidney-bean, spinach, &c. &c."

The writer adds that "some crops require to be cultivated in large quantities, as pease, turnips, onions; others in small portions, as most sallad and pot-herbs. Some require very rich soil, and generally, manure, previously to planting or sowing, as celery, cauliflower, and leeks; others require a tolerably rich soil, but are much injured by manure immediately previous to their insertion, as carrot, beet, and most esculent roots of fusiform shapes."

In regard to modes of culture, it is suggested that culinary vegetables may be distinguished "into, 1st, such as are sown upon the surface broadcast, as onions, turnips, spinach, &c. 2d. Such as are sown or planted on the surface but in drills, as pease, beans, and potatoes. 3d. Such as are placed in hollow trenches, as celery, and sometimes artichokes. 4th. Such as are sown or raised on beds or ridges, as asparagus, sea-kale, and frequently early crops of pease, &c. 5th. Some require the soil to be often pulverized while growing, as potatoes, pease, and most drill-crops; others admit of it but in a small degree, as onions, leeks, carrots, &c. Some are occasionally and often materially injured by it, as strawberries.

In relation to duration, it is observed that some are sown and removed within three months: as early crops of turnips, radishes, brassica plants, for removal, &c.; others continue double that time, as onions and potatoes; others treble, as frequently brocoli and cabbages; some continue two seasons, as parsley, fennel, &c.; others for several years, as strawberries, asparagus, artichokes, &c. By attentively considering these and other divisions which the subject admits of, it is supposed much advantage may be gained by the culinary gardener, and appropriate successions of crops formed: "thus celery, by being planted in hollow trenches, pulverizes the soil in a high degree; by requiring a considerable quantity of manure it enriches it; both which properties are necessary for the production of plants of large, ramose, or fasciculate roots, which penetrate deep into the soil, such as artichokes, scorzonera, asparagus, &c. Again, these crops by remaining long on the soil, afford, when removed, an excellent situation for such as are more transitory, as pease, potatoes, &c."

After-management.—There are scarcely any two plants that require exactly the same means in the whole of their cultivation, though in many instances the differences are but very small. In the annual and biennial kinds, the similarity in many cases is very considerable; but in that of the perennial sallad and pot-herb sorts it mostly differs in a high degree. Whatever the nature of the culture that is requisite may be, in any sort of plant or vegetable, it should always be executed in due season, and under proper circumstances in respect to the state of the ground. There are several other matters in the performance of this business that require the attention of the gardener, as will be seen under their proper heads.

Useful and important alterations and changes are capable of being produced in vegetables, by diverting their natural and usual habits of growth and production. A very plain and easy method of accomplishing this, in many cases, is by setting and sowing, at unusual periods, as between those in which it is usually performed. The same thing is also capable of being effected by making use of different sorts of soil for the purpose, as such as are more early or late, in conse-

quence of their natural qualities. As the great or final purpose of every individual vegetable is that of the production of its flower, fruit, and seed, it naturally pursues its growth till these ends are fully effected; which is the case in very different lengths of time, according to the kind of plant or tree, being short in some, while in others it takes up a very considerable length of time. In this view, by cutting the annual and biennial sorts, so as to prevent these from taking place, they may be continued for several years. And in some cases perennials may be made to afford crops at unusual seasons. The same thing happens to some fruit trees and shrubs when denudated of their leaves and flowers in the late vernal season.

In different fruit-trees that do not usually afford any produce for a great length of time, as the walnut and mulberry, it has been found by Mr. A. Knight, that by grafting them by approach with the bearing branches of old tree, they may be brought into bearing in the course of three years; and it is suggested that this method may probably be applied with success in various other similar cases.

The practical operations of this branch of gardening divide themselves under a variety of different heads, as conservatory, espalier, green-house, hot-bed, hothouse, hot-pit, hot-wall, mushroom-house, orchard, planting, pruning, standard-trees, training, vermin, wall-fruit, wall-tree, watering, watering-engine, weeding, &c.

Names and Sorts of Plants, with Modes of Culture respectively.

Agaricus campestris, the field agaric or mushroom. Cultivated by the spawn of the root, or invisible seed running in lumps of earth or dung, in the autumn season.

Allium, garlick, onion, leek, &c. of the first kind, large white garlick and red garlick—By the cloves of the root when separated.

In the second, or rocambole sort—By the root and bulbs from the stalk.

In the third, or onion kind, as the common oval Strasburg onion, great oval Portugal onion, flat white Spanish onion, flatted Spanish onion, silver-skinned onion, bulbless rooted Welsh onion—By seed annually, which should be sown at different times in the early spring months.

In the fourth sort, as chives or cives—By dividing the roots, and planting them out in the spring.

In the fifth kind, the escalot or shallot—By offsets of the root planted out in spring.

In the sixth sort, or Canada tree-onion—By offset bulbs of the root, and the bulbs at the top of the stalk, planted out in spring.

In the seventh, or the leek kind, as the broad-leaved London leek, narrow-leaved leek—By seed annually, which should be sown in the early spring.

Anethum dill, &c.; common dill—By seed annually, sown in the spring.

Fennel, light-green leaved, dark-green fennel, sweetseeded fennel—By seed sown in spring; also by slipping the old roots, and planting them out in the autumnal season.

Italian fennel—By seed annually, sown in the spring.

Angelica savita, common angelica—By seed annually sown in spring.

Apium, Parsley, celery, &c.; parsley, common plane-leaved parsley, curled leaved common parsley, broadleaved, or large rooted parsley—By seed sown in spring.

Celery, common upright celery, upright celery with solid stalks, turnip-rooted spreading celery—By seed sown in the spring, for transplanting in summer and autumn.

Asparagus officinalis, common asparagus—By seed sown in the autumn, and when once raised, the roots abide for some years.

Atriplex hortensis, garden orach, white-leaved garden orach, green orach, purple orach—By seed annually sown in the spring season.

Beta vulgaris, beet, common culinary beet, greenleaved culinary beet, white beet, chard, or great white Swiss beet, mangel wurzel beet—By seed annually sown in the spring months.

Red beet, large long red-rooted beet, turnip-rooted red beet, red-rooted beet with green leaves, pale-red beet—By seed annually sown in the early spring,

Borago, borage—By seed annually sown in autumn or spring.

Brassica, the cabbage, cauliflower, broccoli, turnip, &c. The cabbage sort, small early summer cabbage, dwarf early sugar-loaf-shaped cabbage, large hollow sugar-loaf cabbage, early Russia cabbage, common round white cabbage, long-sided hollow cabbage, oval hollow cabbage, flat-topped cabbage, musk-scented cabbage, giant cabbage, red cabbage—By seed annually sown at different times, in spring and autumn, for use all the year, by having the plants set out at various times.

Savoy cabbage, common green curled savoy, large green Dutch savoy, yellow

savoy—By seed annually sown in spring, for autumn and winter use.

Lanciniated, and other open-leaved coles, green curled borecole, red curled borecole, thick-leaved curled borecole, finely fringed borecole, broad erect curled-leaved Siberian borecole, or Scotch cole or kale, red and green common plane-leaved green colewort—By seed annually sown in spring and summer, for plants for autumn and winter use.

Turnip cabbage, turnip cabbage with the turnip above ground, with the turnip under ground—By seed sown annually in spring and summer.

The cauliflower sorts, early cauliflower, late cauliflower—By seed sown annually in spring and autumn, for plants for summer and autumn use.

Italian *brassica*, or broccoli, early purple broccoli, late large purple broccoli, comprehending varieties, with blue, brown, green, and yellowish heads, dwarf purple broccoli, white or cauliflower broccoli, black broccoli—By seed sown in spring and beginning of summer, for plants for autumn, winter, and spring use.

The turnip, early Dutch turnip, white round turnip, green-topped turnip, red-topped turnip, yellow turnip, oblong white turnip, long white-rooted French turnip, round purple French turnip—By seed sown in spring and summer, for plants for use most part of the year.

Calendula officinalis, common marigold —By seed sown annually in spring, summer, or autumn.

Cichorium endivia, endive, green curled endive, white curled endive, broad-leaved Batavian endive—By seed sown annually, in summer, from May till July, for plants autumn and winter use.

Cochlearia armoracia, horse radish—By pieces of the roots planted out in spring, for use for most part of the year.

Crambe, sea-cabbage or colewort, the different varieties—By seed sown in spring; but when once raised, the roots remain for years, sending up shoots for use in spring and summer.

Cucumis, cucumber and melon, the cucumber, early short prickly cucumber, early cluster cucumber, long green prickly cucumber, long white prickly cucumber, long smooth green Turkey cucumber, large smooth white cucumber, large smooth green Roman cucumber—By seed sown annually, at different times on hot-beds, in the early spring and summer.

The melon, Romana melon, Cantaleupe melon; varieties of each, and several other sorts—By seed sown annually at different times, on hot-beds, in the spring months.

Cucurbita, the gourd and water melon—By seed sown annually in the spring season.

Cynara, artichoke and cardoon, the common artichoke, globular-headed red Dutch artichoke, ovalheaded green French artichoke—By suckers from the sides of the old plants, in spring, of many years duration.

The common cardoon,—By seeds sown annually in the early spring.

Daucus carota, the carrot, orange-coloured carrot, red carrot, yellow carrot, white carrot—By seed sown annually in spring, summer, and autumn, for use most part of the year.

Helianthus tuberosus, tuberous sun-flower, or Jerusalem artichoke—By pieces of the root planted annually in the spring season.

Hyssopus officinalis, common hysop, the several different varieties.—By seed sown in spring, and by planting slips and cutting of its branches.

Lactuca, lettuce, early green cabbage-lettuce, white cabbage-lettuce, brown Dutch cabbage-lettuce, great admirable cabbage-lettuce, green and white ball cabbage-lettuce, green cos-lettuce, white cos-lettuce, black cos-lettuce, spotted Aleppo cos-lettuce, brown Cilicia lettuce, Imperial lettuce, red Capuchin lettuce, green Capuchin lettuce, curled lettuce —By seed sown annually, at different times, in spring, summer and autumn, for plants for setting out for use most parts of the year.

Lavendula, lavender, spike-flowered common lavender, common narrow-leaved, broad-leaved, blue-flowered, white-flowered, and dwarf lavender—By slips planted out in spring, which are of many years continuance.

Stœchas, or French lavender—By planting slip or cuttings, and by seed, which are of many years duration.

Lepidium sativum, garden-cress, common small-leaved, broad-leaved, curled-leaved—By sowing seed at different times of the year, according as the plants are wanted.

Melissa officinalis, balm, common balm —By dividing and planting the roots in spring or autumn, which are of many years duration.

Mentha, mint, penny-royal, &c., green common spearmint, curled-leaved spearmint, variegated spearmint—By dividing the roots, by young plants, and by cuttings of the stalks, planted out in spring, and which continue many years.

Peppermint—By roots and plants, &c. like the former.

Penny-royal—By dividing and slipping the plants, as for the mint, and planting them out.

Ocymum basilicum, basil, common sweet basil, several varieties—By seed sown in spring on a hot-bed, the plants being afterwards planted out.

Origanum marjoram, common, wild, perennial pot marjoram, winter perennial sweet marjoram, marjorana, or annual sweet marjoram—By sowing seeds in spring, and the two former also, by slipping the roots, and planting them.

Pastinaca sativa, parsnip, common garden parsnip—By seed sown annually for winter use.

Phaseolus vulgaris, common kidney-bean, dwarfs and runners, dwarf kinds, early white, early yellow, liver-coloured speckled dwarf, Canterbury white dwarf, Battersea white dwarf, large white dwarf, cream-coloured dwarf, black dwarf, sparrow-egg dwarf, amber-speckled dwarf—By seed sown annually, at different times, from April till July, or the following month.

Running kinds, scarlet runner, white variety, large Dutch runner, Battersea white runner, negro runner, variable runner—By sowing the seed like the former, but principally in the summer months.

Pisum, the pea, Charlton pea, golden Charlton, earliest golden Charlton, long Reading hotspur, Master's hotspur, Spanish morotto, green nonpareil, early dwarf-marrowfat, large marrowfat, green rouncival, or union, white rouncival, Ledman's dwarf pea, small sugar pea, large sugar pea, cluster pea, crown pea, egg pea, sickle pea, &c.—By seed sown annually, at different times, from October till June, but principally in the early spring months.

Portulaca olevacea, purslane, green purslane, golden purslane—By seed sown different times in April and May.

Piterium sanguisorba, burnet, common garden burnet—By seed sown in autumn or spring, and parting the roots.

Raphanus sativus, the radish, short-topped early radish, long-topped radish, deep-red radish, pale-red, transparent, mild radish, salmon-coloured radish, small white turnip-rooted radish, small red turnip radish, large white turnip-rooted Spanish radish, large black turnip-rooted Spanish radish—By seed sown at different times, from Christmas till July or August; but the latter sorts sown principally in June and July, for autumn and winter use.

Rosmarinus, rosemary, some varieties —By planting layers, slips, and cuttings in spring.

Rumex acetosa, sorrel, comom long-leaved sorrel, round-leaved French sorrel, barren sorrel—By parting the roots, and the first sort also plentifully by seed.

Ruta graveolens, rue; several varieties —By planting slips and cuttings; also by seed.

Salvia, sage, clary, &c. The sorts are, common sage, red sage, broad-leaved green sage, narrow-leaved green sage, broad-leaved hoary sage, sage of virtue, wormwood sage, &c.—By planting slips in April, May, and June; also by sowing the seed in the spring season.

Clary—By seed sown annually in the spring

Satureja, savory, winter perennial savory, summer annual savory—Both by seed sown in the spring season, and the former also by planting slips.

Scandix cerefolium, chervil, annual garden chervil—By seed annually, in August, for winter and spring use or sown also in spring and summer, for succession crops.

Scorzonera, scorzonera, Spanish scorzonera—An eatable root, raised from seed sown in spring.

Sinapis, mustard, white mustard, black mustard, field or wild mustard; the former to use young in sallad, and the two last for their seeds, to make the table sauce called mustard—By seed in spring; or, if for sallads, at any time of the year.

Sium sisarium, sisariun or skirret—An eatable root raised by planting offsets, commonly, of the root; also by seeds.

Smyrnium olusatrum, Alisanders, or common Alexanders—By seed annually in spring.

Solanum, night-shade, furnishing the potatoe and tomatoe, tuberous-rooted solanum or potatoe, the common sound red potatoe, early round red, oblong red, deep red, pale red, rough red, white kidney-shaped, large red-ended kidney, white round, white cluster, prolific American—By planting pieces of the roots or the roots whole in spring; also by sowing seed occasionally to obtain new varieties.

Tomatoe or love-apple; varieties—By sowing the seed annually, on a hot-bed, in the spring.

Spinacia, spinach, round thick-leaved or smoothseeded, triangular leaved or prickly seeded; the former for spring and summer crops, the latter to stand the winter—By sowing annually in spring, summer, and autumn, for use most part of the year.

Tanacetum vulgare, common tansey—By parting the roots, and planting in spring or autumn.

Thymus vulgaris, common thyme, the varieties with broad leaves, with narrow leaves, with striped leaves—By sowing

seeds in March and April; also by planting slips of the roots and branches, and by cuttings; but seed is the only way to raise a quantity of the common sort; and the other methods to continue the varieties, or for a general supply.

Tragopogon porrifolium; salsafy—An esculent root, by seeds annually in spring.

Tropæolum, Indian cress, or nasturtium, nasturtium minus, nasturtium majus; their flowers for garnish and sallads, and their seeds to pickle—Raised annually from seeds sown at different times in spring.

Valeriana locusta, corn sallad or lamb's lettuce—By seed sown in spring and autumn.

Vicia faba, the bean, early Mazagan, early Lisbon, long-pod, Turkey long-pod, toker bean, Sandwich bean, Windsor bean, white-blossomed, red-blossomed, Spanish bean, nonpareil bean, dwarf fan bean, very low—By seed sown annually, at different times from October until June, but principally in the early spring months.

KOUMISS, a vinous preparation of milk, which see.

L.

LABORATORY. In the language of chemistry a laboratory is a place, room, apartment, or house fitted up with furnaces, instruments, apparatus, &c. for the purpose of conducting experiments, or for manufacture. The scientific or experimental chemist requires, for conducting his operations, which are designed principally for discovery or philosophical purposes, a number of instruments, and an apparatus; but the practical chemist or manufacturer whose object is different, needs only a few articles which are designed for conducting his processes. Thus the pharmaceutical chemist, whose object is the manufacture of sundry articles used in medicine, has his laboratory arranged or fitted up with a few furnaces, sand baths, and stills. Every process, such as dyeing, the fusion and casting of metal, and the like, although chemical in a degree, are conducted with apparatus of a different kind. Such establishments receive the name of the dye-house, foundery, &c. and the operator is called a dyer, founder, &c. instead of receiving the name of chemist. We have, therefore, in treating of sundry processes, given some account of the apparatus employed, as well as the particular processes. See Dyeing, Colour Making, Glass Making, Salt Making, &c. We do not consider it of importance to notice the best plan and arrangement of a chemical laboratory; but under the different heads we shall notice the apparatus used in the arts.

LAC, (Gum.) *Lacque,* Fr—Gum-Lac, as it is usually termed, is a substance properly neither a gum nor a resin, but a very singular compound, which is prepared by the female of a very minute insect, the Coccus Lacca, which is found on a few species of trees in some parts of the East Indies, particularly on the Banyan Fig, and the Rhamnus Jujuba or Biher. The insect is nourished by the tree, fixing itself upon the twigs and extremities of the succulent branches, where also it deposits its eggs, which it glues to the branch by a red semi-pellucid liquid, the outside of which hardens in the air and also serves as a cell for the parent insect. This gradually increases, and when at its greatest size appears as an oval smooth red bag, full of a beautiful red liquid. When the eggs are hatched, the young insects appear first to feed upon the inclosed liquid, and after this is expended they eat through the investing coast, leaving a hollow red resinous bag which is the *Stick Lac.* The lac therefore appears in the economy of the insect to answer the double purpose of food and protection to the young animal, and, when examined, each bag is found to be in distinct cells like a honey-comb, but of different shape.

For the purification, it is broken into small pieces, and put into a canvas bag of about four feet long, and not above six inches in circumference. Two of these bags are in constant use, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to pass through its pores; when it is taken off the fire, and twisted in different directions by the men who hold it, at the same time dragging it along the convex part of a plantain tree prepared for this purpose; and while this is doing, the other bag is heating, to be treated in the same way. The mucilaginous and smooth surface of the plantain tree prevents its adhering; and the degree of pressure regulates the thickness of the coating of lac, at the same time

that the fineness of the bag determines its clearness and transparency.

Lac is an article of great importance in many arts and in commerce. The best is procured from the province of Akam, but it is found in great abundance on the uncultivated mountains on each side of the Ganges.

The only trouble of collecting the rough or stick-lac is that of breaking down the branches and carrying them to market; but for the purpose of dyeing it is taken before the young insects have eaten their way througth the bag, that is while the red liquor remains within it.

The best lac is of a deep-red colour, and the liquid within the cells has a sweetish taste, which in India is used immediately as a dye being miscible with water.

There are four kinds of lac known in commerce, namely—

1. Stick lac, which is the lac in its natural state, without any preparation.

2. Seed-lac, which is the former kind broken into small lumps, granulated and picked.

3. Lump-lac, which is seed lac liquified by fire.

4. Shell-lac, which is the cells of the stick lac, liquified by gentle heat, strained and formed into thin transparent laminæ in the following simple manner.

It is broken into small pieces and picked from the branches and sticks and put into a canvas bag. This is placed over the fire, and frequently turned till the lac is liquid enough to pass through its pores, when it is taken off and squeezed by two men in different directions dragging it along the convex part of a plantain tree prepared for the purpose. The degree of pressure on the plantain tree regulates the thickness of the shell.

Of the above three sorts of lac only the stick, shell, and seed lac are known in commerce.

There is besides a white or yellowish lac brought from Madagascar, highly resembling the pe-la of the Chinese, which has been very ably examined by Dr. Pearson.

The three species of common lac have lately been analyzed by Mr. Hatchett.

Alcohol dissolves a large portion of all the kinds of lac. When heat is not used the solution contains a part of the colouring extract, and a large quantity of a *resin* which may be separated from the solution by evaporation or by adding the solution to water, acidulated with muriatic or acetic acid and heating, when the resin will form a curdy coagulum. The portion soluble in *cold* alcohol, and which is entirely resin, except a little extract amounts to about 68 per cent from stick-lac, 88 per cent. from fine seed-lac, and 81 per cent. from shell-lac, but in the latter case about 10 more of resin remain mixed with the other ingredients. Hot alcohol dissolves also other parts of the lac which are not easily separable again.

Lac is found by experiment to consist of a colouring extract of resin, gluten, and wax, all of them in intimate combination, but separable almost entirely by a judicious order and selection of the different re-agents.

The general properties of each of these ingredients are the following:

1. The extract when dry is of a deep crimson; soluble chiefly but not totally in water, hot or cold; less so in alcohol, but the residue after the action of alcohol dissolves in water; insoluble in ether; partially soluble in muriatic and acetous acid, giving a red liquor which is changed to purple by alkalies; is totally soluble in acetic acid; and equally so in the alkalies. When pure alumine is put into the aqueous solution, and a few drops of muriatic acid added, a beautiful coloured lake is precipitated. A fine precipitate is also formed by muriat of tin.

2. The resin is brownish yellow, soluble in alcohol, ether, acetic acid, nitric acid, potash, and soda, and is precipitable by water from all these solvents except the two last.

3. The gluten is obtainable in two ways: if the pieces of lac after digestion in alcohol be digested with dilute acetic or muriatic acid, most of the gluten is dissolved, and may be precipitated by alkalies added in due proportion; but is redissolved by an excess of them, and then is separable by acids. It much resembles the gluten of wheat.

4. The wax is found floating like oil on the solution of lac after long boiling in nitric acid, which takes up every thing else, and congeals when cold; or it may be more easily procured, by first digesting the lac with cold alcohol, and treating the residuum with boiling nitric acid, which will separate the wax.

Thus obtained it is white, of the consistence of bees wax, melts at a less heat than boiling water, and burns with a white flame and smell like spermaceti. It is insoluble in cold alcohol, but with a boiling heat a portion is dissolved, most of which separates by mere cooling, and the remainder by affusion of water. Potash boiled with the wax forms a milky solution, but the chief part of the wax floats at the top, and seems to be converted into a kind of soap, hardly solu-

ble, and inflammable. Acids separate the remainder of the wax from the alkaline solution.

The three different species of lac being analyzed, gave the following proportions: 100 parts of stick-lac gave 68 of resin, 10 of colouring extract, 6 of wax, 5.5 of gluten, and 6.5 of extraneous substances: 100 parts of seed-lac gave 88.5 of resin, 2.5 of extract, 4.5 of wax, and 2 of gluten: 100 parts of shell lac gave 90 9 of resin, 0.5 of extract, 4. of wax, and 2.8 of gluten.

Lac is employed for a variety of purposes in the arts, both in India and else where. The finer pieces of shell-lac are cut into ornaments of various kinds, such as beads and necklaces; the shell-lac enters largely into the composition of sealing wax, and hard japans or varnishes, hence called *lacquers*, and lac is also used for dyeing. For this last the stick-lac is the only kind employed, as the colouring matter chiefly resides in the extract, of which the shell-lac contains a very small proportion, but on the other hand as this has much more resin, it is greatly preferable for varnishes and lacquers. A composition of rough angular sand melted with lac is much employed in India as the material for grindstones, which are cast into a circular shape, and when well managed, they cut very fast. The lapidaries use corundum powder instead of sand, and form with lac a composition for grinding and polishing gems.

LAC (*White*) } LACCIC ACID. } A white or yellowish-white waxy matter, the production of insects, and called in Madras *White lac*, was first particularly noticed by Dr Henderson about the year 1786, and supposed by him to resemble very closely the *Pe-la* of the Chinese, or white wax used in varnishes, for candles, &c. Some of this white lac sent over to England about the year 1793, was examined by Dr. Pearson.

The white lac is in grey, opake, rough, roundish pieces, of about the size of a pea. It has a saltish and bitterish taste, but when fresh gathered it appears from Dr. Anderson's account to have a sweetish and delicious flavour. On pressing the pieces between the fingers, a saltish liquid oozes out. White lac has no smell unless when rubbed. After melting and straining it sinks in water.

If obtained largely it probably might prove of much use in the arts.

LAC SULPHURIS, is sulphur separated by acids from its alkaline solution. It is somewhat altered in the process, and changes its lemon-yellow colour for a grey or yellowish-white, like cream.

It is thought to be somewhat milder as a medicine. See SULPHUR.

LACE. When several threads of gold, silver, silk, or thread, are interwoven and worked on a cushion with spindles, according to the desired pattern, the stuff called lace is formed. There are various kinds of lace, such as Point, Brussels, or Flanders lace, and bone lace made in England. To restore gold or silver lace when tarnished, various liquors have been recommended, as spirits of wine, solution of soap, of potash, &c. The gold or silver may be separated from lace, by boiling the lace in soap ley, after which the stuff will become softened, and, by means of a mallet, the separation may be readily effected.

LACQUERING. Lacquering is the laying either coloured or transparent varnishes on metals, in order to produce the appearance of a different colour in the metal, or to preserve it from rust, or the injuries of the weather.

Lacquering is used where brass is to be made to have the appearance of being gilt; where tin is wanted to have the resemblance of yellow metals; and where brass locks or nails, or other such matters, are to be defended from the corrosion of the air or moisture.

The principal substance used for the composition of lacquers, is seed-lac; but, for coarser purposes, resin or turpentine is added, in order to make the lacquer cheaper.

A Lacquer for Brass, to imitate Gilding.—Take of turmeric one ounce, and of saffron and Spanish annotto, each two drachms. Put them into a proper bottle with a pint of highly rectified spirits of wine, and place them in a moderate heat, often shaking them for several days. A very strong yellow tincture will then be obtained, which must be strained off from the dregs through a coarse linen cloth; and then, being put back into the bottle, three ounces of good seed-lac, powdered grossly, must be added, and the mixture placed again in a moderate heat, and shaken till the seed-lac be dissolved, or at least such part of it as may. The lacquer must then be strained, and must be put into a bottle well corked.

Where it is desired to have the lacquer warmer or redder than this composition, the proportion of the annotto must be increased; and where it is wanted cooler, or nearer to a true yellow, it must be diminished.

The above, properly managed, is an extremely good lacquer, and of moderate price; but the following, which is cheaper, and may be made where the Spanish an-

notto cannot be procured good, is not greatly inferior to it.

Take of turmeric root, ground, one ounce, of the best dragon's blood half a drachm. Put them to a pint of spirits of wine, and proceed as above. By diminishing the proportion of dragon's blood, the varnish may be rendered of a redder or truer yellow cast.

Saffron is sometimes used to form the body of colour in this kind of lacquer, instead of the turmeric; but though it makes a warmer yellow, yet the dearness of it, and the advantage which turmeric has in forming a much stronger tinge in spirits of wine, gives it the preference. Though being a true yellow, and consequently not sufficiently warm to overcome the greenish cast of brass, it requires the addition of some orange coloured tinge to make it a perfect lacquer.

Aloes and gamboge are also sometimes used in lacquers for brass; but the aloes is not necessary where turmeric or saffron is used; and the gamboge, though a very strong milky juice in water, affords but a very weak tinge in spirit of wine.

A Lacquer for Tin, to imitate a Yellow Metal.—Take of turmeric root one ounce, of dragon's blood two drachms, and of spirits of wine one pint; add a sufficient quantity of seed-lac.

A Lacquer for Locks, &c.—Seed-lac varnish alone, or with a little dragon's blood: or a compound varnish of equal parts of seed-lac and resin, with or without the dragon's blood.

A Gold coloured Lacquer for gilding Leather.—What is called gilt leather, and used for skreens, borders for rooms, &c. is only leather covered with silver leaf, and lacquered with the following composition.

Take of fine white resin four pounds and a half, of common resin the same quantity, of gum sandarach two pounds and a half, and of aloes two pounds; mix them together, after having bruised those which are in great pieces, and put them into an earthen pot, over a good fire made of charcoal, or over any fire where there is no flame. Melt all the ingredients in this manner, stirring them well with a spatula, that they may be thoroughly mixed together, and be prevented also from sticking to the bottom of the pot. When they are perfectly melted and mixed, add gradually to them seven pints of linseed oil, and stir the whole well together with the spatula. Make the whole boil, stirring it all the time, to prevent a kind of sediment that will form, from sticking to the bottom of the vessel. When the varnish is almost sufficiently boiled, add gradually half an ounce of litharge, or half an ounce of red lead, and when they are dissolved, pass the varnish through a linen cloth, or flannel bag.

The time of boiling this varnish should be about seven or eight hours. This, however, varies according to circumstances. The way of knowing when it is sufficiently boiled, is by taking a little on some instrument, and if it draws out and is ropy, and sticks to the fingers, drying on them, it is done; but if not, it must be boiled till it acquires these qualities. See VARNISH.

LACTIC ACID. See MILK.

LAKES. A lake may be defined to be an intimate combination of colouring extract, with an earth, or metallic oxyd, formed by precipitation from the solution of the colouring matter. Thus, if a solution of alum is added to an infusion of madder, a mutual decomposition takes place, and part of the alumine falls down intimately united with the colouring matter of the madder. This separation is much assisted by an alkali.

The lakes form some of the beautiful pigments, and are much used in water-colour painting, and other purposes. They are almost invariably composed either of alum, or sometimes the solutions of tin, and some other watery solution of a colouring matter.

In addition to what we have said on the subject of lakes, in other parts of our work, the following observations may prove useful in this place.

The principal lakes are, Carmine, Florence-lake, and lake from Madder.

For the preparation of Carmine, four ounces of finely pulverized cochineal, are to be poured into four or six quarts of rain or distilled water, that has been previously boiled in a pewter kettle, and boiled with it for the space of six minutes longer; (some advise to add, during the boiling, two drachms of pulverized crystals of tartar.) Eight scruples of Roman alum in powder are then to be added, and the whole kept upon the fire one minute longer. As soon as the gross powder has subsided to the bottom, and the decoction is become clear, the latter is to be carefully decanted into large cylindrical glasses covered over, and kept undisturbed, till a fine powder is observed to have settled at the bottom. The superincumbent liquor is then to be poured off from this powder, and the powder gradually dried. From the decanted liquor, which is still much coloured, the rest of the colouring matter may be separated by means of the solution of tin, when it yields a carmine little inferior to the other.

For the preparation of Florentine lake, the sediment of cochineal, that remained in the kettle, may be boiled with the requisite quantity of water, and the red liquor likewise, that remained after the preparation of the carmine, mixed with it, and the whole precipitated with the solution of tin. The red precipitate must be frequently edulcorated with water. Exclusively of this, two ounces of fresh cochineal, and one of crystals of tartar, are to be boiled with a sufficient quantity of water, poured off clear, and precipitated with the solution of tin, and the precipitate washed. At the same time 2 pounds of alum are also to be dissolved in water, precipitated with a lixivium of pot-ash, and the white earth repeatedly washed with boiling water. Finally, both precipitates are to be mixed together in their liquid state, put upon a filter, and dried. For the preparation of a cheaper sort, instead of cochineal, one pound of Brazil wood may be employed in the preceding manner.

The red extracted from shreds of scarlet cloth by boiling them in a lixivium of a pound of pearl ashes to two quarts of water, being precipitated by a solution of a pound and half of cuttlefish bone in a pound of aqua fortis, is said to make a very fine carmine. If 1½lb. of the bone be not sufficient to saturate the aqua fortis, more must be added, till it excites no effervescence. If the lake appear too purple, a little alum may be added to the solution.

For the following process for making a lake from madder, the Society of Arts in England, voted sir H. C. Englefield, their gold medal. Enclose two ounces troy of the finest Dutch crop madder in a bag of fine and strong calico, large enough to hold three or four times as much. Put it into a large marble or porcelain mortar, and pour on it a pint of clear soft water cold. Press the bag in every direction, and pound and rub it about with a pestle, as much as can be done without tearing it, and when the water is loaded with colour, pour it off. Repeat this process till the water comes off but slightly tinged, for which about five pints will be sufficient. Heat all the liquor in an earthen or silver vessel, till it is near boiling, and then pour it into a large basin, into which a troy ounce of alum, dissolved in a pint of boiling soft water, has been previously put. Stir the mixture together, and while stirring, pour in gently about an ounce and half of a saturated solution of subcarbonat of potash. Let it stand till cold to settle; pour off the clear yellow liquor; add to the precipitate a quart of boiling soft water, stirring it well; and, when cold, separate by filtration the lake, which should weigh half an ounce. If less alum be employed, the colour will be somewhat deeper: with less than three-fourths of an ounce, the whole of the colouring matter will not unite with the alumine. Fresh madder root is equal, if not superior, to the dry.

Almost all vegetable colouring matters may be precipitated into lakes, more or less beautiful, by means of alum, or oxide of tin; but Guyton-Morveau asserts, that the oxide of tungsten is superior to any other base. If this oxide were boiled in vinegar, so as to give it a blue colour, the tints of the lake were heightened. From the fermented juice of the succotrine aloe he obtained a fine purple red with this oxide. See Colour-Making.

LAMP-BLACK. There are two species of lamp-black in common use; one is the light soot from burning wood of the pine, and other resinous kinds; and the other is a heavy black, prepared from bones, by calcining them in close vessels.

In addition to what we have said on lamp-black, under Colour-Making, we may add, that its preparation is dependent on the making of common rosin: the impure resinous juice, collected from incisions made in pine and fir trees, is boiled down with a little water, and strained, whilst hot, through a bag: the dregs and pieces of bark left in the strainer are burnt in a low oven, from which the smoke is conveyed through a long passage, into a square chamber, having an opening on the top, on which a large sack made of thin woollen stuff is fixed; the soot, or lampblack, concretes partly in the chamber, from whence it is swept out once in two or three days, and partly in the sack, which is now and then gently struck upon, both for shaking down the soot, and for clearing the interstices betwixt the threads, so as to procure sufficient draught of air through it. In this manner lampblack is prepared at the turpentine houses, from the dregs and refuse of the resinous matters, which are there manufactured. See Colours.

LEAD.—Lead is a metal of a bluish-grey colour, is malleable, ductile, and inelastic: it is very soft, is fusible at less than a red heat, is easily oxydable by exposure to the air when melted, and its oxyd is easily fusible into a transparent yellow glass.

Ores of Lead.—Sp. 1. Galena.

Of this there are the two following subspecies.

1. *Subsp.* Common Galena.

Its colour is a more or less perfect lead-

grey, inclining in some varieties to blackish; it sometimes presents superficially, an iridescent tarnish. It occurs in mass, disseminated or investing; also in particular shapes, such as globular, reniform, specular, reticulated, cellular, cylindrical, &c. also crystallized.

The crystals are rarely large, but generally middle-sized or small; either grouped one upon the other, implanted, or solitary. Their planes are commonly smooth, sometimes drusy, rarely carious or rough. The external lustre of galena varies, according to its surface, from resplendent and specular to glimmering Internally it varies from specular to glistering, and its lustre is metallic. Its fracture is lamellar, either plane, curved, or divergent; this latter passes into radiated, the rays being short and broad. It is divisible in a three-fold rectangular direction, hence its fragments are cubical. When in mass it is often composed of granular and rarely of lamellar distinct concretions. It is soft, somewhat sectile, easily frangible. Sp. g. 6.56 to 7.78.

Before the blowpipe it decrepitates, then melts, giving out a sulphureous odour, and when this ceases a globule of metallic lead remains behind.

Galena consists essentially of lead and sulphur, in the proportion of about 100 of the former, to 15 of the latter; but, besides these ingredients, iron pyrites, grey antimony, copper, gold, and silver, are found in various proportions, besides different earthy ingredients, chiefly lime and silex. The following are some of the most recent and accurate analyses that have been made of this ore.

	From Kirschwald, in Deux Ponts.		Kampfstein.		Ecklerberg.		Kantenbach.		Cologne.
Lead	54.	—	69.	—	68.69	—	64.	—	63.1
Sulphur	8.	—	16.	—	16.18	—	18.	—	12.
Carbonated lime and silex	38.	—	15.	—	16.13	—	18.	—	19.67
Oxyd of iron	0.	—	0.	—	0	—	0	—	3.33
	100		100		101		100		98.1

The above analyses were made by Vauquelin, to which we shall subjoin an analysis of galena from Durham, by Dr. Thomson.

Lead	85.13
Sulphur	13.02
Oxyd of iron	0.5
	98.65

The proportion of silver in galena varies greatly, from $\frac{1}{300}$ or less, to $\frac{1}{12}$; it is observable that the presence of this metal considerably impairs the lustre of galena, and that it is much more frequently found in the octohedral than in the cubical varieties of this mineral. The presence of antimony is commonly indicated by a tendency to the radiated fracture.

It is next to pyrites the most common of metallic ores, and is found in beds and veins in primitive, transition, and secondary mountains. It occurs most abundantly in argillaceous schistus and secondary limestone, and is almost always accompanied by blende and calamine. To enumerate the places where it is found, would be to mention almost all the mineral districts that are known.

Lead is found in abundance in Louisiana, and in various other districts, in the United States. In England, it is found in Cornwall, Devonshire, and Somersetshire; in Derbyshire, in Durham, and the contiguous boundaries of Lancashire, Cumberland, and Westmoreland; in Shropshire, in Flint and Denbighshire, in Merioneth and Montgomeryshire; at the lead-hills in Scotland, on the borders of Dumfrieshire and Lanarkshire, in Ayrshire, and at Strontian in Argyleshire.

Most of the lead of commerce is procured from this ore; it is also made use of without any further preparation as a glazing for coarse pottery.

2. *Subsp.* Compact galena.

Its colour is similar to but generally somewhat lighter than that of the preceding subspecies. It occurs in mass, disseminated and specular (the specular in Derbyshire, is known by the name of *slikenside*). The specular variety is splendent externally, the others are only glimmering. Internally all the varieties are slightly glistening with a metallic lustre. Its fracture is even, passing into flat conchoidal. Its fragments are indeterminately angular. It acquires a polish by friction; is more tender than the preceding subspecies, and agrees with it in the rest of its characters. Sp. gr. 7.44.

In its habitudes with the blowpipe, it differs from common galena in not decrepitating on the first application of heat.

It occurs in veins with common galena, and always occupies the sides of the vein. It is not very common.

Sp. 2. Triple Sulphuret of Lead.

Its colour is dark grey, inclining to black. It occurs crystallized. Its primitive figure is a rectangular tetrahedral prism, besides which it presents other varieties.

The crystals are large and middle sized, with a splendent metallic lustre both externally and internally. Its fracture is coarse-grained, uneven. In hardness it ranks between calcareous and fluor spar; is very brittle and easily frangible. It leaves a faint black trace when rubbed on paper. Sp. gr. 5.76.

When suddenly heated before the blowpipe it crackles and splits, but if gradually heated it melts, and on cooling forms a globule of a dull metallic-grey colour; by further exposure to the flame a white and somewhat sulphureous vapour is disengaged, consisting of sulphur and antimony, and there remains behind a crust of sulphuretted lead, inclosing a globule of metallic copper. It has been analyzed by Mr. Hatchett, with the following result.

17.	Sulphur.
42.62	Lead.
24.23	Antimony.
12.8	Copper.
1.2	Iron.
97.85	
2.15	Loss.
100.	

It has hitherto been found only in the mine Huel-Boys, in Cornwall.

Sp. 3. Blue Lead Ore.

Its colour is intermediate between lead-grey and indigo-blue; it also passes sometimes to smoke-grey and black. It occurs sometimes in mass, but usually crystallized in small six-sided prisms, perfectly equiangular, often a little bulging, and the external surface of which is somewhat rough and dull. Internally it possesses a feebly-glimmering, metallic lustre. Its fracture is even, passing into fine-grained uneven and flat conchoidal. Its fragments are indeterminately angular. It is opake, gives a shining metallic streak, is soft, somewhat sectile, and easily frangible. Sp. gr. 5.46.

It fuses readily before the blowpipe, then burns with a weak blue flame, giving out a penetrating sulphureous vapour, and is reduced to a metallic globule.

It has not been regularly analyzed. Klaproth discovered in it some phosphoric acid, and the other constituent parts are probably sulphur and oxyd of lead.

It has hitherto been found only at Zschoppau in Saxony, in veins accompanied by black and brown lead ores, carbonat of lead, malachite, quartz, fluor spar, and heavy spar.

Sp. 4. Carbonet of Lead.

Its colour is greyish or yellowish-white, yellowish-grey, cream-yellow, and light clove-brown, sometimes, though rarely, dark ash-grey. It occurs massive, disseminated, and superficial; but most frequently crystallized. Its primitive figure is a rectangular octahedron, divisible parallel to the common base of the two pyramids of which it is composed.

The crystals are usually small, rarely middle-sized, either solitary or in groups: their surface is generally specular and splendent, sometimes a little rough or striated, and then only glistening. Internally its lustre varies from highly resplendent to glistening, and is that of the diamond, inclining on the one hand to semi-metallic, and on the other to resinous. Its fracture is small conchoidal, passing into fine-grained uneven and fine splintery or imperfectly fibrous. Its fragments are indeterminately angular. It varies from transparent to translucent, and is in a remarkable degree doubly refracting. It is soft, brittle, and easily frangible. Sp. gr. 6.0 to 7.2.

Before the blowpipe it decrepitates, becomes yellow and then red, and if heated on charcoal is immediately reduced. It effervesces slightly in cold nitrous or muriatic acid, but more vigorously if the menstruum is warmed. It is blackened by hydrosulphuret of ammonia. It is often confounded with columnar heavy spar, but may be readily distinguished from this by its superior specific gravity and its habitudes with the blowpipe and hydrosulphuret of ammonia. There are several analyses of this ore, but perhaps the most satisfactory are the following.

From Zitterfeld, by Westrumb.		From-Leadhills, by Klaproth.	
Oxyd of lead	81.2	77	Lead
Carbonic acid	16.	5	Oxygen
Oxyd of iron	0.3	16	Carbonic acid
Lime - - -	0.9	2	Water and loss
	98.4	100	

Carbonat of lead is almost always accompanied by galena, and appears to be more frequently found in argillaceous schistus than in any other kind of rock. It is by no means a rare mineral, but seldom occurs in sufficient quantity to be worth separating from the adhering spar, &c. for the purpose of smelting. The finest specimens of this ore that are found in Britain come from the mines of Derby-

shire, of Lead-hills in Scotland, and Minera in Denbighshire, at which last place the compact variety is remarkably abundant. It also occurs in the United States.

Sp. 5. Black Lead Ore.

Its colour is greyish-black passing into smoke-grey. It occurs in mass, disseminated or cellular, or crystallized in six-sided prisms, either simple or terminated by dihedral summits.

The crystals are small and grouped confusedly in groups. Their surface is sometimes smooth, sometimes striated longitudinally. Externally it is splendent or shining. Internally it is shining or glistening, with a lustre approaching to semimetallic. Its fracture is fine-grained uneven, passing into imperfectly conchoidal. Its fragments are indeterminately angular. It is opake, or at most translucent on the edges. It gives a greyish-white streak; it is moderately hard, brittle, and easily frangible. Sp. gr. 5.77.

Before the blowpipe it decrepitates, and is quickly reduced to a metallic globule. It has recently been analyzed by Lampadius, and appears to consist of

72.	Lead
7.	Oxygen
18.	Carbonic acid
2.	Carbon
99	

It occurs in veins of galena, principally of the most recent formation. It usually occupies the upper part of the vein, incrusting galena, and being itself covered by carbonat or green phosphat of lead. It is found in the Lead-hills in Scotland; in Bohemia and Saxony; in Brittany in France, and in Siberia.

Sp. 6. Muriat of Lead.

Its colour varies from the palest grey to wine-yellow. It occurs crystallized in cubes, either simple or terminated by tetrahedral pyramids, or bevelled on the edges. The crystals are middle-sized and small, and have a splendent vitreous lustre. The principal fracture is foliated, the cross fracture conchoidal. It is transparent or semi-transparent. It is much softer than carbonated lead; and is easily frangible. Sp. gr. 6.05.

When heated on charcoal before the blow-pipe it runs into an opake orange-coloured globule, which on cooling becomes first yellow and then white. At a high heat the globule suddenly spreads over the charcoal, the acid flies off in vapours, and there remain behind minute grains of metallic lead.

It has been analyzed by Klaproth and Mr. Chenevix with the following results.

85.5	—	85	Oxyd of lead
8 5	—	8	Muriatic acid
6.0	—	6	Carbonic acid
100.0		99	

It has hitherto been found only at Matlock in Derbyshire, upon galena.

Sp. 7. Brown Phosphat of Lead.

Its colour is hair-brown, passing on one side into grey, and on the other into clove-brown. It occurs rarely in mass, but generally crystallized in lengthened six-sided prisms, sometimes so slender as to become capillary. The surface of the crystals is blackish and rough: internally it is glistening, with a resinous lustre. Its fracture is small grained uneven passing into fine-splintery. Its fragments are indeterminately angular. It is more or less translucent, gives a white powder, is soft, moderately brittle, and easily frangible. Sp. gr. 6.6 to 6.9.

Before the blowpipe it melts very easily, but is not reduced to the metallic state; by cooling it concretes into a radiated mass. It does not effervesce with acids.

According to Klaproth it consists of

Oxyd of lead - - - -	78.58
Phosphoric acid - - -	19.73
Muriatic acid - - - -	1.65
	99.96

It occurs in veins at Huelgoet in Brittany, at Miess in Bohemia, near Schemnitz in Hungary, Saska in the Bannat, and Zschoppau in Saxony.

Sp. 8. Green Phosphat of Lead.

Its usual colour is olive-green, but it also exhibits several other shades of green, such as grass-green, greenish-white, pistachia, and yellow-green, whence it passes into sulphur-yellow. It occurs sometimes in mass, or reniform or botryoidal, but most commonly crystallized.

Its primitive form is the pyramidal dodecahedron, consisting of two six-sided pyramids joined at their bases.

The crystals are generally small, either solitary or in groups. Sometimes the crystals are so minute as to appear like a fine down.

The surface of the crystals is smooth and shining; internally they are glistening, with a resinous lustre. The fracture is small-grained uneven, verging sometimes upon splintery. Its fragments are indeterminately angular. It is translucent, very rarely semi-transparent. Its hardness is superior to that of carbonated lead; it gives a greenish-white powder, is brittle, and easily frangible. Sp. gr. 6.2 to 6.9.

Before the blowpipe it becomes of a

greyish-white and melts very easily, without decrepitation, into a globule; but shows no sign of reduction. If the globule is cooled slowly it forms a polyhedral striated solid. It is soluble difficultly, and without effervescence in the mineral acids.

The three subsequent varieties of this mineral have been analyzed by Klaproth with the following results.

Yellowish-green phosphat, from Zschoppau.	Grass-green phosphat, from Hoffsgrund in the Brisgau.	Lemon-yellow phosphat, from Wanloch-head.	
78.	77.1	80.	Oxyd of lead
18.37	19.	18.	Phosphoric acid
1.7	1.54	1.62	Muriatic acid
0.8	0.1	0.	Oxyd of iron

A specimen from Erlbach on the other hand was found by Vauquelin to contain

45.18	Lead
18.7	Phosphoric acid
4.05	Oxygen
32.	Silex
99.93	

This mineral is found in veins both in primitive and secondary mountains, but chiefly in the former of these. It is accompanied for the most part with galena, carbonat of lead, and iron ochre, with quartz, heavy spar, and calcareous spar.

It is met with in Bohemia, Saxony, Bavaria, the Brisgau, France, Scotland, and Siberia.

Sp. 9. Sulphat of Lead.

Its colour is greyish or yellowish-white, passing into smoke and ash-grey. It has been found only crystallized. Its primitive figure is an octohedron, composed of two tetrahedral pyramids with rectangular bases.

Externally the crystals are smooth and shining; internally they are splendent with a vitreous lustre. The fracture of this mineral is compact. It is more or less transparent passing into translucent. It is soft, somewhat brittle, and easily frangible. Sp. gr. 6.3.

Before the blowpipe it decrepitates on the first application of the flame, but when previously pulverized it melts into a brilliant scoria, which by continued ignition on the charcoal is reduced to metallic lead. It has been analyzed by Klaproth with the following results.

From Anglesey.	From Wanloch-head.	
71.	70.55	Oxyd of lead.
24.8	25.75	Sulphuric acid
2.	2.25	Water
1.0	0.	Oxyd of iron
98.8	98.5	

It occurs in veins of galena at Wanloch-head, and in the province of Andalusia in Spain, and in a bed of cellular quartz with iron pyrites and iron ochre at Parys mine in Anglesey.

Sp. 10. Arseniat of Lead.

Of this there are two subspecies.

1. *Subsp.* Reniform Arseniat.

The colour of the recent fracture is brownish-red, but by exposure to the air it passes into ochre and straw-yellow. It occurs in reniform masses, the surface of which is rough and uneven. Internally it is glistening with a resinous lustre. Its fracture is conchoidal. It occurs in coarse-granular distinct concretions; is opake; gives a dull orange-yellow streak; is soft and brittle. Sp. gr. 3.92

Before the blowpipe it melts, emits an arsenical odour, and at length is converted into a black shining globule, in which grains of lead are observable.

According to an analysis by Bindheim it consists of

35.	Oxyd of lead
25.	Arsenic acid
1.5	Silver
14.	Iron
7.	Silex
3.	Alumine
10.	Water
95.5	

It has hitherto been found only at Nerstchinsk in Siberia.

2. *Subsp.* Green Arseniat of Lead.

Its colour varies from meadow-green to wax-yellow. It occurs in needles, in fine filaments, in compact masses, and granular concretions. Its lustre varies from silky to resinous. It is translucent, moderately brittle, and easily frangible. Sp. gr. 5.04.

Before the blowpipe it gives out an arsenical vapour, and is reduced to a metallic globule.

It occurs in veins with galena in Andalusia in Spain, and in the departments of the Saone and Loire in France.

The arsenico-phosphat of lead of Hauy may probably also be referred hither. Its colour is yellowish-green; it occurs in mamillary masses, studded with brilliant

points. Before the blowpipe it gives out an arsenical odour. It contains, according to Fourcroy, by whom it has been analyzed,

50	Oxyd of lead
29	Arsenic acid
14	Phosphoric acid
4	Oxyd of iron
3	Water
100	

It is met with in a mine at Rosiers in Auvergne.

Sp. 11. Molybdat of Lead.

Sp. 12. Chromat of Lead. See CHROME.

Sp. 13. Lead of Ochre.

Of these there are two subspecies.

1. *Subsp.* Indurated.

Its colour is yellowish or greenish-grey, straw-yellow, apple-green, smoke-grey, and light brownish-red. It occurs in mass. Internally it is glimmering or glistening, with a resinous lustre. Its fracture is fine-grained uneven, passing into fine splintery and earthy, also into flat conchoidal. It is opake or at most slightly translucent on the edges. It gives a brownish streak; is soft, passing into friable; is not very brittle, but is easily frangible.

It is reducible before the blowpipe, effervesces with acids, and is blackened by hydro-sulphuret of ammonia.

It occurs with the other ores of lead, and is usually accompanied by iron pyrites and malachite.

2. *Subsp.* Friable.

Its colour is yellowish-grey approaching to sulphur-yellow. It occurs massive, disseminated, and superficial. It is composed of dull, dusty, friable particles; is meagre and rough to the touch, and is heavy.

It is found to accompany galena and the other ores of lead, and is found at Wanloch-head and the Lead-hills in Scotland, in the Hartz and Saxony, in Poland, and Siberia.

Smelting and Reduction of Lead Ore.— The only ore of lead that is wrought in the large way is galena, and the method of treating this is very simple, partly on account of the richness of the ore and partly on account of the low price of the metal itself, which therefore will not admit of any but the most summary methods of bringing it into a marketable state.

The ore when first brought up from the mine is dressed by women and boys, who with a hand-hammer separate the greater part of the adhering impurities, consisting of blende, iron pyrites, quartz, calcareous spar, &c. The residue being broken into pieces about the size of a hazle-nut is washed from all adhering clay and dirt, and is then ready to be smelted. The furnace used for this purpose is the common reverberatory, with a low arch. A ton or more of the ore is spread on the floor of the furnace, and by means of the flame from pit-coal it is quickly brought to a bright red heat. In this situation it is occasionally stirred with iron rakes to expose fresh surfaces to the action of the flame and facilitate the separation of the sulphur. In a short time the mass begins to acquire a pasty consistence; upon which the heat is lowered and the ore is kept at a dull red till the sulphur is nearly all got rid of; the fire being then increased the ore is brought to a state of perfect fusion, and visibly consists of two fluids; the lower is the metallic lead, the upper is a vitreous slag, still holding a considerable portion of lead but mixed with various impurities. In this state of the process the fire is damped and a few spadefuls of quicklime are thrown into the fluid mass; by this the scoriæ are suddenly solidified, and are raked to the side of the furnace; the tap-hole is then opened, and the lead runs into moulds placed to receive it, where it congeals into oblong masses called pigs, weighing about 60 lbs each. As soon as the lead has run out of the furnace, the tap-hole is closed, the scoriæ are replaced in the bed, and being quickly raised to a glowing red heat are soon melted; the greatest part of the lead that they contained by this means collects into a mass at the bottom; a little lime is thrown in as before, the scoriæ thus rendered solid are raked aside, and the lead which they covered is let off into a mould. This second scoriæ, though still holding from 5 to 8 per cent. of lead, is now removed from the furnace, and applied to no purpose but that of mending roads, the expence of separating the last portions of metal being more than the value of the produce.

The lead of the first running is the best; that procured from the scoriæ being sensibly harder, and less malleable on account of the iron that it contains.

It is a matter of doubt among the most intelligent smelters whether there is any advantage in retaining the carbonat of lead, with which the galena is very often mixed in considerable proportion. On the one hand it is certain that it contains a large quantity of metal, and in assays is very easily reducible; but on the other hand, when treated in the reverberatory, it vitrifies almost at the first impression of the heat, and being a very active flux it is apt to bring the whole into fusion while much sulphur still remains unsublimed;

hence the amount of scoriæ is prodigiously increased, and with it the trouble of the smelters, while the produce of lead is very little augmented.

Citizen Duhamel, in his Memoir on the Refining of Lead in the large way, has given a sketch of the process used in England.

The object of refining lead is not merely on account of the silver it contains, but to procure it as free as possible from the other metals with which it is usually alloyed, and to procure litharge. The silver is only an object so far as it helps to pay the expense of refining.

The lead produced at the smelting hearths or furnaces in England is never perfectly pure; it is always alloyed with a portion of silver, and most commonly with one, or most of the following metals; namely, zinc, antimony, copper, and arsenic; which render it unfit for some of the purposes to which lead is applied.

The operation of refining is founded on the facility with which lead is oxidated when exposed to heat in contact with atmospheric air, and the peculiar properties the oxides of lead possess; being easily fused, and in that state oxidating and combining with most of the metals; gold, silver, and platina excepted.

The lead to be refined is exposed to the action of heat and air upon a *cupel* or *test*, composed of a mixture of bone and fern ashes in a reverberatory furnace.

The refining furnace is composed of good solid masonry, bound together with iron bolts. It differs very little in its construction from the common reverberatory furnace, except the bottom, which is perforated to receive the test or cupel.

A good test is of the first importance in refining; the method of constructing one we shall endeavour to point out. Six parts of well burnt bone ashes and one part of good fern ashes are to be well mixed, sifted through a sieve, (the spaces in which are about one-eighth of an inch square,) and moistened to about the same degree the founders use their sand. The iron frame is to be laid on the floor and made steady, with wedges under its rim; about two inches in thickness of the ashes are to be equally spread over the bottom, and with an iron beater, such as used by the founders, equally rammed between the cross bars; the frame is to be again filled and rammed all over, beginning at the circumference and working spiral ways until finished in the centre, the filling and ramming to be repeated until the frame is completely full; an excavation to contain the lead is made as expressed in the plan, with a sharp spade about five inches square, the edges dressed with a long-bladed knife; a semi-eliptical hole, is to be cut through the breast. Having proceeded so far, the test is to be turned on its side and dressed from all superfluous ashes adhering to the bottom, taking care that none shall be left flush with the bottom of the frame or cross bars, otherwise in fixing the test to its situation at the bottom of the furnace it would be liable to be bulged.

Fixing the Test in its situation.—The rim of the test is now to be plastered with clay or moistened ashes, placed upon the supporting cross bars, and fixed with wedges firmly against the botttom of the furnace, the breast next to the feeding hole.

A gentle fire may now be lighted, and gradually increased until the test be red hot. When it ceases to emit steam from the under side it is sufficiently dry.

Lead previously melted in the iron pot is ladled into the test until the hollow part be nearly filled, the operator closes the feeding aperture, and increases the heat of the furnace until the surface of the lead is well covered with litharge; he then removes the door from the feeding hole, and with an iron rod, which has one end bent down at right angles about three inches and made flat or chissel-shaped, scrapes the small gutter or channel until the litharge just flows into it, the blast from a pair of double bellows is then directed from the back part over the surface of the test, the litharge is urged forward, and flows from the gutter upon the floor of the refinery; the operation now goes forward, gradually adding lead as the escape of litharge makes it necessary, until the gutter is so worn down that the test does not contain more than an inch in depth of lead; the blast is then taken off, the gutter filled up with moistened ashes, and a fresh one made on the other side the breast; the test is again filled, though not so full as at first, and the operation carried on until this gutter also is worn down and the test contain from about fifty to seventy pounds of alloy. This quantity is run into an iron pot, and set by until a sufficient number of pieces have been collected to make it worth while to take off a plate of pure silver from them.

The quantity of alloy left, in the working off each test must depend in a great measure upon the quantity of silver it, by estimation, is supposed to contain. A sufficient quantity of lead should always be left in the alloy to make it fuse easily in the iron pot.

When the test is removed from the

furnace and broken up, the litharge will be found to have penetrated to an inconsiderable but equal depth in the ashes; that part not impregnated with litharge may be pulverised, mixed with fresh ashes, and again used for another test.

The operation of taking off the silver pure, differs in no respect from the foregoing, only more care is observed in the working, not to suffer the escape of any metallic particles with the litharge, as that would occasion considerable waste of silver. As the process advances, and the proportion of silver to lead increases, the litharge assumes a darker colour, a greater heat becomes necessary, and at last the brightening takes place; the interior of the furnace, which during the whole of the process had been very obscure and misty, clears up. When the operator observes the surface of the silver to be free from litharge, he removes the blast of the bellows, and suffers the furnace to cool gradually; as the silver cools many protuberances arise on the surface, and fluid silver is ejected from them with considerable force, which falling again on the plate spots it very fantastically with small globules.

The latter portions of litharge bring over a considerable quantity of silver with them; this is generally reduced by itself and again refined.

The litharge as it falls upon the floor of the refinery is occasionally removed; it is in clots at first, but after a short time as it cools it falls for the most part like slacked lime, and appears in the brilliant scales it is met with in commerce: if it is intended as an article for sale, nothing more is necessary than to sift it from the clots which have not fallen and pack it in barrels.

If, on the contrary, it is intentded to be manufactured into pure lead, it is placed in a reverberatory furnace, mixed with clean small-coal, and exposed to a heat just sufficient to fuse the litharge. The metal as it is reduced flows through an aperture into an iron pot, and is cast into pigs for sale. During the reducing, care is taken to keep the whole surface of the litharge in the furnace covered with small-coal.

In some smelt works, instead of a reverberatory furnace for reducing, a blast furnace is made use of, on account of the greater produce, but the lead so reduced is never so pure as that made in the wind furnace. The oxides of the metals, which require a greater heat to reduce than the lead, are in the blast furnace generally reduced with it.

The volatile oxides, as zinc, antimony, and arsenic, are mostly carried off by evaporation during refining; a considerable portion of the oxide of lead itself is carried off by evaporation, making the interior of the furnace so misty and obscure that a person unused to refining cannot see more than a few inches into it.

A considerable portion of these oxides are driven by the blast of the bellows through the feeding aperture, and would be dissipated in the refining-house, to the great injury of the workmen's healths.

Lead is a metal of a blueish-white colour, almost silver-white, when recently melted, but very soon tarnishes. It gives a peculiar smell when rubbed or heated. Its specific gravity, according to Brisson, is 11,352. It is very malleable, readily extending under the hammer into very thin leaves; but its tenacity is less than that of any other metal, for a wire one tenth of an inch in diameter will break with a weight of 30 lbs.

Lead is the least sonorous of all the metals, giving, when struck, a very flat heavy sound. It melts long before being red-hot. The melting point of this metal has been variously given, owing to the known irregularity of the mercurial thermometers at very high temperatures.

Morveau gives it at 590° Fahr. According to Mr. Crichton, it is 612°. When slowly cooled, it crystallizes in quadrangular pyramids. Heated fully to redness it smokes and sublimes in the open air, giving a grey oxyd, which settles on the sides of the vessel that contains it, or if in large quantity, mixes with the atmosphere around, and collects in the chimnies of the furnaces where it is melted. Lead in all forms and combinations, is poisonous when taken in any quantity, and a frequent exposure to its vapour, or much handling it, gradually produces dangerous bowel-complaints, paralytic symptoms, and other maladies.

Though the surface of lead at a common temperature soon tarnishes, this metal will remain exposed to air, and all weathers, for a great length of time without further change, the oxidated surface protecting the inner part from destruction, and hence the durability of leaden roofs, pipes, &c. but yet in process of time the whole is corroded throughout.

Water has but little direct action on this metal either hot or cold, not being decomposed by it as it is by iron and some other metals; but it slowly assists the action of the air, for lead will be corroded sooner in a damp than in a dry atmosphere.

When lead is melted in free exposure

to the air, it becomes almost immediately covered with a wrinkled pellicle of a dirty grey colour, and if this is skimmed off others form in succession, till the whole metal is changed into a yellowish-grey oxyd, the weight of which was one of the earliest observations made on the effect of calcination in increasing the weight of metals.

This grey oxyd, by a further continuance of heat with constant stirring, passes through various shades of a greenish-yellow to a deep dun-yellow, owing to a successive absorption of oxygen. The highest state of oxygenation to be produced by mere calcination, appears to be that in which the oxyd has a beautiful high red colour, with more or less scarlet, when it is called *Minium* or *Red Lead*, a substance well known as a pigment, and especially as a flux in glass-making, for which it is largely employed.

Minium, however, cannot be made with any certainty in the small way by mere calcination in the air, however long this is continued, the colour of the oxyd never rising higher than a dun yellow; it is only produced in manufactories in the large way, with frequent stirring. The process for making red lead, is thus described by Dr. Watson, as carried on in Derbyshire.

The furnace is very much like a baker's oven, with a low vaulted roof, and on each side of the furnace are two party-walls, rising from the floor of the surface, but not reaching to the roof. In the interval between these walls and the sides of the furnace, the coal is burned, and the flame draws over the top of the party-walls, and striking the roof is thence reflected down upon the surface of a quantity of lead, which is laid on the floor of the furnace. The metal soon melts, and instantly becomes covered with a pellicle, which is successively raked off till the whole is changed into a greenish-yellow powder. This is taken out, ground in a mill, and washed, to separate the portion of lead that still remains in the metallic state, by which it becomes an uniform yellow colour, and is then thrown back into the furnace and constantly stirred, so that every part may be equally exposed to the action of the flame, and in about forty-eight hours of calcination it is converted into *red lead.*

Some practical nicety is required in the management of the fire, which, if too slack, gives only a yellow or orange coloured powder, and if too fierce makes the minium dusky, and destroys that brilliant gloss for which it is so much admired. There are, besides, other minuter circumstances of management, and probably kept secret as much as possible. Jars mentions in particular, that of cooling the minium when made very gradually, and closing all the openings of the furnace, otherwise the beauty of colour is much impaired. Some makers also sprinkle the surface with water occasionally, during the calcination.

In Holywell, minium is made from litharge, which saves the previous calcination.

A portion of the lead in the process of conversion into minium, is always lost by volatilization, part of it being dissipated in the air, and another part settling in the chimnies, and on the roofs of the furnace, in the form of a yellowish-white soot, with crystallized lumps intermixed. which is collected from time to time, and either reduced into lead, or is mixed with the lead in the subsequent calcination. The quantity of this sublimate collected, according to Watson, is about $\frac{1}{400}$ of that of the minium produced, but of course must vary greatly. On this account, and from the loss by entire volatilization in the air, it is impossible to ascertain, directly, the full increase of weight which the lead should acquire by conversion into minium. The actual increase is, on an average, about a tenth, twenty hundred weight of lead producing twenty-two hundred of minium.

It has been mentioned, that the oxyd of lead becomes yellow before it turns red. The substance called *Massicoc*, and used as a yellow pigment, is generally made of this yellow oxyd; but the finer sorts are said to have an addition of muriat of ammonia, and to be therefore a muriated oxyd of lead, or approaching to that fine pigment, called the Naples yellow, which will be afterwards noticed.

Litharge is another of the oxyds of lead, made by the simple action of heat and air. It is produced in the process of extracting the silver from lead, as will be more fully described under that article. The silver-holding lead, is put into a large shallow dish made of ashes, and therefore very porous, and is kept till red-hot in a wind-furnace, at the back of which enters the pipe of large bellows that direct a blast of air on the surface of the red-hot metal. This converts it into a scaly yellowish-white glistening oxyd, which is raked off successively to expose new surfaces, till nearly the whole of the lead is thus changed into litharge. There are slight variations in the colour of litharge, some kinds having more of a silvery gloss, others being of a dead red-yellow. Part of it is again reduced into very pure and soft lead, and the rest is selected for sale. The waste of lead by volatilization, is many

times more in reducing lead into litharge than into minium; so that, though there is a large gain of oxygen from the air, the litharge weighs less than the lead from which it was produced. Part of it, however, is lost by soaking into the test, a porous vessel in which it is made.

All the oxyds of lead, when strongly heated to a full redness, very readily run into a glass which has a clear topaz-yellow colour, and is the most powerful flux known of every vitrifiable matter; so that, in a very short time, the vitrified oxyd corrodes all the common crucibles, and runs through them like a sieve, and even the closest porcelain can only retain it for a time. Minium, in vitrification, always gives out a quantity of oxygen gas; but the quantity varies much, even in the same sample, and is never so much as 8 per cent. During the vitrification, a portion of the minium is spontaneously reduced to the metallic state, and is found at the bottom of the crucible. A fuller account of the vitrifying power of the oxyds of lead, will be found under the article GLASS.

The *yellow oxyd* of lead is that which appears to be the basis of by far the greater number of the salts of this metal, and therefore is of primary importance. It is formed in the calcination of this metal *per se*, and is formed at so early a period that it is probably the first change that this metal undergoes by union with oxygen, though, as already mentioned, the colour is not obvious at first, on account of being mixed with metallic lead finely attenuated, and not yet oxygenated, which debases the colour to grey or yellowish-green, till it is separated by washing. *Massicot* is the yellow oxyd, as pure as it can be formed by mere calcination, but as this is changed to *minium* by continuing the process, the yellow oxyd made by heat can never be procured so uniform as by solution.

There is yet another oxyd of lead to be noticed, which is the *brown oxyd*.

In this the lead is at the highest state of oxygenation. It was first discovered by Scheele and many of its distinguishing properties noticed by him. It is procured by adding nitric acid to minium. The experiments of Scheele are the following:

If finely powdered minium be dissolved in nitrous acid, diluted with a triple quantity of water, a black or brown powder remains, which is the oxyd in question. This is not soluble in the acid by itself, but on adding a little sugar a clear solution is immediately obtained. The same happens with dilute vitriolic acid. If muriatic acid be poured on the black powder, an effervescence takes place when warmed, and a strong smell of aqua regia (oxymuriatic acid) rises, the powder becomes white, and is turned into common white muriat of lead. If the oxyd be distilled by itself in a glass retort, it grows yellow and becomes in every respect similar to the common yellow oxyd of lead, and is then entirely soluble in nitrous acid, and no longer gives any smell of oxymuriatic acid.

It may be of use to recapitulate all the oxyds and carbonated oxyds of lead in the supposed order of oxygenation, (beginning with the lowest) with their leading properties, premising, that this is a subject in which there are still many points of uncertainty which it would not be very difficult for future experiments to clear up.

The sub-oxyd, stated by Proust to be formed by boiling the nitrat of lead with reguline lead. The existence of this is doubtful.

The yellow oxyd, presumed to be the basis of most of the salts of lead, particularly the common nitrat from which its proportions have been deduced. It is produced either by heating minium till it no longer gives out oxygen, or by calcining the solid nitrat (in both of which cases it is mixed with reduced lead) or more accurately by heating the white carbonat nearly to melting, or by decomposing the salts of which it is the basis by caustic alkali. It gives no oxygen gas when heated even to melting. It contains, according to Proust, 9 per cent. of oxygen, and according to Thomson about 10 per cent. It yet remains to be proved whether it does not acquire some other ingredient from the long-continued calcination with coal-flames besides oxygen.

Massicot is the yellow oxyd formed by the calcination of lead in its progress to the state of minium, and probably resembles the yellow oxyd very closely, but is less uniform in its composition.

Minium or *red oxyd* is formed by long-continued calcination of lead, is insoluble as such in acids, apparently from being too highly oxygenated. Its composition is variously stated, and probably really varies according to the circumstances of manufacture. Vauquelin states it to contain generally no more than 9 per cent. of oxygen; Thomson, 12 per cent. and others somewhat higher.

Though it gives out oxygen when heated, and passes to the yellow oxyd, this is not an unexceptionable proof of its containing more oxygen, on account of the entire reduction of a portion which always takes place, but the strongest proof of

its super-oxygenation is derived from the action of nitric acid as already described, and its separation into two oxyds, of which the least oxygenated is the yellow oxyd, but if it is really the basis of the sulphat of lead it would appear to contain no more than about 7 per cent.

The brown oxyd is formed by the further oxygenation of minium, is insoluble as such in acids, with muriatic acid gives oxymuriatic acid gas, gives out much oxygen on being heated, and contains, according to Thomson, 18.4 per cent. of oxygen, and according to Proust 21 per cent.

Litharge, according to Thomson, is the yellow oxyd combined with about 4 per cent. of carbonic acid.

The white carbonat is the yellow oxyd fully saturated with carbonic acid and water, both of which are driven off at a red heat and the yellow oxyd left pure.

All the pure oxyds or carbonated oxyds of lead are reducible with great ease when heated red hot in contact with carbonaceous matter. It is not necessary to mix them with any reducing flux, nothing more being required in the way of experiment than to lay them in a covered crucible lined with charcoal. The same reduction takes place when heated by the blowpipe on charcoal.

When strongly heated per se, and especially in a draught of hot air, the oxyds of lead partly volatilize during vitrification.

Lead is soluble in most acids. All the salts have a sweetish taste, and are strongly styptic or astringent in the mouth.

Prussiat of potash causes a white precipitate, and all the hydrosulphurets a deep black-brown precipitate, even in very minute quantities, so as to furnish an excellent test for the presence of this metal.

The *carbonic acid* unites readily with the oxyd of lead, forming (as already mentioned) the white carbonat when fully saturated, and in a less proportion, converting the yellow oxyd to the state of litharge. The proportions of these two carbonats have been already given. The white carbonat is produced by decomposing the nitrat or any other salt by a carbonated alkali. Water holding carbonic acid will readily dissolve enough of the oxyd of lead by remaining some time in contact, so as to be very readily detected by the hydro-sulphurets.

Cerusse or *white lead* is a carbonat prepared in the first part of the process of making acetite of lead. It is made in the following way: lead is melted and cast in a case or mould, so as to form a sheet about two feet long, five inches broad, and from one-sixteenth to one-fourth of an inch thick. The lead in this instance is cast at once of the proper form, and not mechanically flattened like sheet lead, that its texture may be more open, and more easily penetrated by the acid vapour. These plates are then rolled up into a loose coil, and each is laid perpendicularly in an earthen pot, like a common garden-pot, holding from two to six pints each, but with a ledge on the inside about half way down on which the coil of lead rests, so that it may not touch the bottom. Each pot is filled with vinegar of any kind, just so high as not to wet the bottom of the lead, and the whole is also covered with a plate of lead fitting very close. The pots are then ranged under a building, so as to shelter them from the weather, and buried pretty deep in fresh stable litter or Tanner's bark, layer upon layer, according to the number of pots. The heat of the dung soon fills the upper part of the pots with the vapour of the vinegar below, and the lead kept constantly in contact with the acid vapour, but not immersed in the liquor, presently begins to corrode and oxidate at the surface. The pots remain under the litter for about two months, at the end of which time they are taken out and the coils of lead are found deeply corroded and the surface converted into a whitish scaly brittle oxyd. This is separated by passing the plates between rollers, which causes it to peel off, leaving the lead beneath in the metallic state. This oxyd is then mixed with a little water, and passed between a pair of mill-stones; then the finer parts are separated from the coarser by successive washings, the former being longer suspended in water than the latter, till the whole of the finer oxyd is obtained. This is then dried either in the air or in large airy rooms warmed by a small stove, and is then perfect cerusse or white lead fit for use. Of late years the scales of oxyd, instead of being separated from the coils by dry laminating, which raised a dust of lead highly injurious to the health of the people about them, are detached by spreading the coils upon a perforated wooden floor covered with water, and drawing them to and fro by rakes, which detaches the oxyd and causes it to sink through the water and the holes of the floor to the bottom of the vessel below.

The cerusse or white lead thus formed was found by Bergman to be a carbonated oxyd of lead, and not an acetite or subacetite, though the acetous acid is the means of its formation.

The *acetous acid* does not dissolve lead

when in close vessels, but with access of air it first oxidates it, and then dissolves the oxyd. Or the solution may be made by adding oxyd of lead or carbonated oxyd to vinegar, and digesting for a time.

Acetite of lead, commonly called *sugar of lead*, is a salt used very largely in manufactures, particularly in calico-printing, and the preparation of it, though very simple, is confined to a very few places and countries. Most of the sugar of lead used in England is imported from Holland. This salt is made very nearly in the manner of cerusse, that is, lead sheets are put into pots with vinegar and digested a sufficient time, but here the vinegar is distilled, and the plates, instead of being entirely out of the liquor, are half immersed in it. This being done, the upper half is soon covered with an efflorescence of cerusse, after which it is immersed in the vinegar, and the part which was before immersed is now brought up to be converted into cerusse as before, when the plate is again turned, and the newly oxydated surface in its turn buried in the liquor. The plates are thus turned about two or three times a day, and the vinegar in saturating itself with the cerusse has become milky, and soon sufficiently impregnated to be boiled down to the crystallizing point, which is done in tinned vessels to about a third of the original quantity. This is then strained, and, on cooling, deposits the acetite in small long-needled irregular whitish crystals. The mother-liquor is again evaporated for a fresh crop of crystals, but these are browner and somewhat deliquescent.

Acetite of lead may also be made directly by dissolving cerusse or litharge in vinegar, and probably the natural carbonat will answer the same purpose. Some technical nicety appears to be required in making the salt crystallize in the large way.

Sugar of lead has a remarkably sweet taste, by no means unpleasant, but mixed with considerable astringency. By re-solution in boiling water and slow cooling, it changes its appearance considerably, and assumes the form of large transparent tetrahedral prisms or lengthened parallelopepids. Carbonic acid in any form decomposes this salt, and causes a white carbonat to be precipitated, and hence one cause of the milkiness which it usually assumes with spring water; but this is also partly owing to the sulphats contained in most natural springs.

When dry acetite of lead is briskly heated without addition in a retort, it gives an acetous red fetid liquor, and the residue of the distillation furnishes a good pyrophorus. But Proust, in distilling it very slowly, obtained first a watery vinegar, then a yellow liquid with the smell of alcohol but rather empyreumatic, from which after a time ammonia was disengaged, and from which, when saturated with potash, a strong smelling etherial oil separated. The liquid distilled from the solution furnished a strong inflammable fluid resembling ether.

Litharge boiled with vinegar to entire saturation forms a reddish-brown solution, universally known in medicine as Goulard's extract, and it seems to contain much more oxyd of lead than the common acetite.

Lead and nitre have but a very weak action on each other. When lead filings are projected on melted nitre, little if any deflagration is excited, but the metal is reduced to a yellow semi-vitrified foliated mass resembling litharge.

The action of the oxyds of lead on the alkaline muriats is attended with some striking phenomena. In the numerous experiments for obtaining the alkali from muriat of soda, it was found that litharge was able completely to decompose this salt and produce a white mass, whilst the naked alkali remained in solution. This discovery has been applied to use in the large way on account of the fine yellow pigment which is obtained from the white mass by calcination, and for which a patent was procured many years ago by Mr. Turner.

Turner's Patent Yellow, or the sub-muriat of lead made yellow by heating, is thus made according to the specification of the patent: take any quantity of minium, litharge, or calx of lead, add half the weight of common salt, with water sufficient to dissolve it, mix them by long trituration, and let them stand together at least for twenty-four hours, by which time the lead will be changed into a good white; then wash out the alkali and calcine the lead till it becomes yellow; which will be of different tints according to the continuance of calcination and degrees of heat. As only twice as much litharge as salt is here employed, it is probable that some of the salt remains undecomposed.

The oxyds of lead readily decompose muriat of ammonia. If this salt and minium are rubbed together even without heat, a strong smell of ammonia rises, and by distillation properly conducted, caustic ammonia may be prepared in this way as well as by muriated ammonia and lime. If litharge be used, some carbonat of ammonia is also obtained, and with the white carbonat of lead the entire ammoniacal product is carbonated. The residue in

each case is muriat of lead, in the form of a grey brilliant brittle mass. See Colour Making.

The fat oils dissolve the oxyds of lead with great ease, and undergo a remarkable change in the process, being thereby rendered drying, or capable of speedily hardening into a firm varnish when exposed to the air. Some oils, particularly olive oil, acquire at once a very firm consistence and a considerable adhesive property, when gently warmed. It is in this state the common white diachylon plaster. See the article Oil.

Lead is capable of uniting with many other metals, forming alloys, some of which are of use in the arts.

Four parts of lead and one of antimony form, according to Rinman and other authors, the common type-metal of the letter-founders, though some add a little copper or brass. This resembled the last-mentioned alloy in appearance, and would not take a polish. Sp. gr 9.571.

Eight parts of lead and one of antimony gave an alloy very like pure lead, but harder and more sonorous, and of a close granular texture like steel. Sp. gr. 11. Twelve of lead and one of antimony gave an alloy scarcely less malleable than lead, and capable of extending into very thin leaves.

Antimony therefore is found to harden lead very considerably, and hence its use in type-metal, and also probably in bullets, where greater hardness is required, but it does not add materially to its lustre, except in a quantity which totally destroys the malleability.

Lead and bismuth unite with great ease, and form alloys of remarkable fusibility, particularly with a small addition of tin, as described under the article Bismuth.

Lead and cobalt unite but with difficulty, forming an unimportant alloy. See Cobalt.

Lead alloyed with copper forms pot-metal. See Copper.

For the important alloy of lead and tin, see Tin.

Lead and zinc do not unite readily unless by particular management.

The ores of this metal are abundantly found in the mine counties of England, and in various other parts of the globe. Its uses are numerous, and scarcely need be mentioned. Its oxides have been already mentioned as of great use, as pigments, and in the manufacture of glass. Lead is cast into thin sheets for covering buildings, making water-pipes, and various other uses; and this is rolled between two cylinders of iron, to give it the requisite uniformity and thinness. Lead is thought, and with some reason, to be not perfectly innocent even for water pipes, and much less for any other kind of vessels. The workmen in any of the preparations of lead are generally subject to a peculiar cholic and paralytic disorders; which most probably arise from the internal use of the metal; for it is a fact, that these workmen are not sufficiently cautious in washing their hands, or removing such particles of lead, or its preparations, as may casually intermix with their food.

A patent was granted in 1779 to Mr. W. Roe, for his new-invented process of extracting sulphur from poor lead ores, and rendering these as valuable, and saleable, as any other ores of this metal. As this patent is now expired, and the principle of the inventor is equally simple and ingenious, we trust it is, or will be, generally adopted in smelting-houses: the inquisitive reader will find it fully specified in the 6th vol. of the "*Repertory of Arts and Manufactures*."

The plumbers cast thin sheets of lead upon a table or mould covered with woollen, and above this a linen cloth, without burning or scorching the cloths.

The melted lead is received in a wooden case without a bottom; which, being drawn down the sloping table by a man on each side, leaves a sheet of its own width, and more or less thin, according to the greater or smaller celerity of its descent. For thick plates, the table is covered over with moistened sand, and the liquid metal conducted evenly over it, by a wooden strike, which bears on a ledge at each side. Some have preferred, for mechanic uses, the milled lead, or flatted sheets.

Lead is put up for sale either in pigs, bars, or sheets. The milled or sheet lead is the dearest, then follow the bars, and the pigs are the lowest sort.

Lead, how formed into shot.—Lead is employed in considerable quantities in the casting of shot, for which a patent was granted in 1782, to Mr. William Watts, in consequence of his invention for granulating lead solid throughout, without those imperfections which other kinds of shot usually present on their surface. The patentee directs 20 cwt. of soft pig-lead to be melted in an iron pot, round the edge of which, a peck of coal-ashes is to be strewed upon the surface of the metal, so as to leave the middle of the latter exposed. Forty pounds of arsenic are next to be added to the uncovered lead, and the pot closely shut; the edges of the lid being carefully luted with mortar, clay, or other cement, in order to prevent the evaporation of the arsenic. A brisk fire

is then kindled, so that the two substances may be properly incorporatad; when the metal ought to be skimmed and laded into moulds, that it may cool in the form of ingots or bars, which, when cold, are called *slag*, or poisoned metal—20 cwt. of soft pig-lead, (according to the quantity of shot intended to be manufactured) are next to be melted in the manner above directed; and, when it is completely liquefied, one of the ingots or bars of slag must be added: as soon as the whole is combined, a small quantity of the liquid metal is to be taken out with a ladle, and dropped from a height of about two feet into the water. If the shot be not perfectly round, it will be necessary to add more slag, till it drops in a globular form. The metal is next skimmed, and the scum poured into an iron or copper frame perforated with round holes, according to the size of the shot designed; the scum is then to be squeezed while soft, through the frame, into which the liquid should be poured, and dropped through the holes. For the smallest shot, the frame must be at least ten feet above the water, and for the largest, about 150 feet; the height being increased or diminished, in proportion to the size of the shot.

Lead White, a machine for working in.—Description of a method of preventing injury to the health of the workmen employed in preparing White Lead. By Mr. Archer Ward, in his own words:

In order to explain, as well as I can, the advantage that will accrue to the workmen by adopting my invention, in preference to the common mode of preparing white lead, I will first state what the common mode is. When blue lead is in part corroded in the stacks, by an acid raised by a considerable degree of heat, brought on by horse-litter, the corroded and uncorroded lead are taken from the stacks to a room, called the engine-loft, where a pair of iron rollers is fixed with a screen under them. The lead in this state is passed through the rollers and screen; from the motion of these rollers and screen, by which the white lead is separated from the uncorroded or blue lead, together with the moving the lead, in order to its being passed through them, a very considerable quantity of fine dusty white lead is raised, which almost covers the workmen thus employed, and is very pernicious to them. And not only in this part of the process are they liable to be thus injured, but they are again exposed to the dusty lead, by removing the blue lead from the screen-house to the furnace, as there still remains a quantity of the fine particles of white lead, which of course rises in removing it; and also, in removing the white lead from under the screen to the grinding-tub, a quantity of the dust arises, which is very detrimental to the people so employed.

My invention removes all these difficulties respecting the dry dusty white lead, so very injurious to the health of the working people; and consists of a vessel, as shown in the plate, fig. 1, twelve feet long, six feet wide, and three feet ten inches deep. In this vessel is fixed a pair of brass rollers in a frame, one roller above the other. The centre of the rollers is about ten inches below the top of the vessel; and, one inch lower, is a covering of oak boards or riddles, an inch thick, fixed in the inside of the vessel, in a groove, so as to be taken out occasionally: these boards are bored, with a centre-bit, as full of holes as may be, without danger of breaking into each other; the size of these holes is, in the machine at large, about five-eighths of an inch in diameter. This being done, the vessel is filled with water, about three inches above the oak boards or riddles; the lower brass roller is now under water, and about half of the upper roller is under water also. Thus the lead coming from the stacks, is put through the brass rollers in water, and, by raking the lead with a copper rake, over the oak boards or riddles, the white lead passes through the riddles, and the blue lead remains above; which, being taken out, is thrown upon an inclined plane of strong laths to drain, where it remains about 12 hours, when the blue lead is ready for the furnace to be re-melted; by this means no dusty white lead can rise in any part to the work-people. No such plan as this (although long desired) has, to my knowledge, been put in execution, so as to answer all the purposes above stated. It may be asked, why the lead in the common mode, is not made wet before it is passed through the rollers and screen. Should this be done, the lead would be a paste on the rollers and screen, and the white lead prevented separating from the blue lead, which is absolutely necessary in the preparation of white lead.

MACHINE FOR WORKING IN WHITE LEAD.

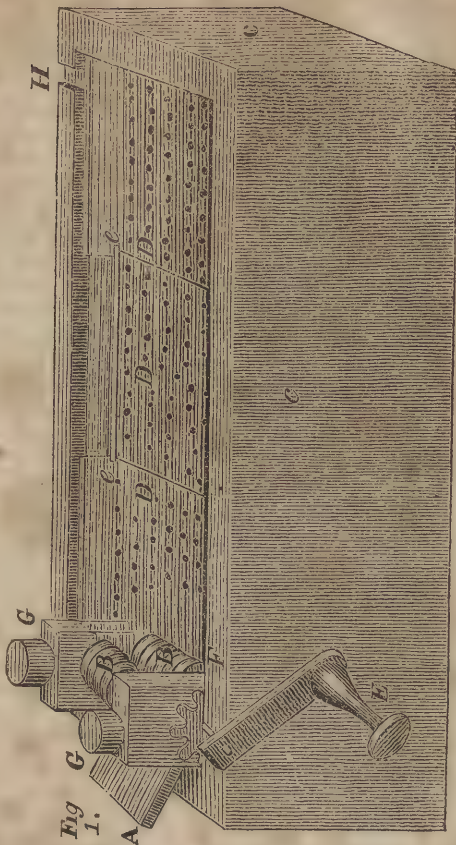


Fig 1.

Reference to the figure.

Fig. 1, A, an inclined plane of wood, on which the white and blue lead is placed immediately from the stacks, and thus introduced between the brass rollers BB.

CC, the vessel containing water.

DDD, the pierced oak boards or riddles, which, by being made to slide in grooves in the sides of the vessel CC, may occasionally be taken out by removing the wooden bar *ee*.

E, a handle or winch. which, in the machine at large, may be a wheel communicating to mill-work, and thus turn the rollers BB.

F, a pinion, fixed on the gudgeon of the upper roller, and communicating with a similar pinion on the arbor of the lower roller, keeping both of them in motion by the turn of the handle. As it is necessary that the upper roller should be at liberty to rise or fall, in order to give a due degree of pressure to the lead in passing between the rollers, two weights GG, with proper stems to them, are placed over the gudgeons of the upper roller, thereby keeping a due degree of pressure; and, if any piece of the lead should be thicker than usual, admitting the roller to give way to it, and thereby preventing any injury to the machinery.

H, a notch in one side of the wooden vessel, serving to regulate the depth of the water on the riddles DDD.

The foregoing description is accompanied by two certificates; one from Mr. Samuel Walker Parker, stating that many tons of white lead have been made, in

the manner above described, at the manufactory at Islington, belonging to Walker, Ward, and Co. and that, since Mr. Ward's plan was adopted, no other method has been used. The other certificate is from Mr. H. Browne, of Irongate, Derby; who says, that he thinks the foregoing invention a very valuable improvement in preparing white lead, and that the quality of the lead is not in the least injured by it.

Mr. Wetherill, of this city, obtained a patent for a somewhat similar contrivance.

Lead, Ores of, American.—The ores of this metal abound in different parts of the United States; but none of the mines produce so much lead as those of Louisiana, from which the greater part of the lead is obtained. As to the situation of the lead mines of Louisiana, and the number of persons employed in mining, every information may be found in Breckenridge's History of the productions of that state. The lead ore is galena, though other ores have been procured, but not in any quantity. In the state of Pennsylvania, lead is found at Perkiomen, and in other districts. The ore is principally sulphuret of lead. In the eastern, as well as in the southern states, this metal also occurs. We shall notice the American ores of lead more fully, under the article ORE.

LEAD, Sugar of or Acetite of Lead. (See the foregoing article.)

LEAD, red
LEAD, Litharge of
LEAD, ores of
LEAD, Submuriate of } See LEAD.

LEATHER.

The preparation of the skins of animals for the many important purposes to which they are applied is almost exclusively a chemical process in all its branches, and as such will deserve a general notice in this place.

The art of preparing leather is unquestionably one of the most ancient known, and is practised in every country on the face of the globe with a general similarity of method, the result of obvious reasoning, and long experience.

The objects fulfilled in converting skin into leather, are, to prevent the destruction by putrefaction, which unprepared skin would undergo (though slower than with most other parts of animals) and to render it strong, tough, and durable, and in some instances impervious to moisture.

The recent skin stripped off an animal consists principally of the true cutis, or membranous texture, the chemical composition of which is gelatin in a dense state, but still entirely soluble in water more or less easily, according to its density. This however is penetrated with different vessels for blood, lymph, oil, &c. some of the contents of which must of necessity remain after the death of the animal, and is covered on the outside with the insensible cuticle, to which is attached the exterior covering of hair, wool, fur, and the like. The chemical composition of the cuticle and its investing hairy covering, appears to be condensed albumen, insoluble in water, and nearly incapable of itself of putrefaction, but readily separable from the true skin by slight mechanical violence after the adhesion has been weakened by incipient fermentation or putrefaction, or the chemical action of lime, alkalies, or acids.

The preliminary steps of all the processes for making leather consist in separating from the cutis adhering impurities and foreign matters, the animal juices retained in its pores, and the cuticle with its hairy covering, (except on the very few cases in which the latter is purposely left on.) The true skin being thus obtained nearly pure, and its texture so far opened as readily to imbibe any substance in which it is macerated, is then converted into leather in different methods, of which there are two quite distinct from each other: namely, that of tanning, or impregnating it with that peculiar vegetable matter called tan, and tawing, in which it imbibes alum and other salts, and afterwards some soluble animal matter, such as the white of egg, or sometimes blood. These two processes are also sometimes combined, that is, first by tawing, and afterwards finishing with a slight tanning. A large portion of the tanned leather also undergoes the further operation of currying, or imbuing with oil of some kind with much manual labour, in order to render it supple, flexible, and still more impenetrable by water. As familiar examples of each, the thick sole-leather of shoes is tanned; the white kid leather, as it is called, for fine gloves, is tawed; the upper leather for boots and shoes is tanned and curried; and the fine Turkey leather is tawed, and afterwards finished with a slight tanning.

The slight variations in the preparation of different kinds of leather are so numerous, that only some of the leading processes can be here described.

Tanned Leather.—All skins undergo a considerable preparation before they are fit to receive the tanning lixivium. In most parts of England the process is the following for the thin skins of cows, calves, and those that are used for the more flexible kinds of leather, most of

which is afterwards finished by currying. The hide is first thrown into a pit with water alone to free it from loose dirt, blood, and other impurities. After lying there for a day or two it is placed upon a solid half-cylinder of stone, called a beam, where it is cleared of any adhering fat or flesh. It is then thrown into a pit containing lime and water, in which it is kept for several days with frequent stirring. The use of this is to loosen the hair and cuticle, after which the hide is again stretched on the beam and the hair entirely scraped off with a blunt knife made for the purpose. The hide being well freed from the lime is then put into a pit called the mastering-pit, which is a bath composed of water and the dung of some animal, generally hens or pigeons, or dogs, or, where it can be had, of sea-fowl, diffused through the water. The dung of horses or cows will not answer, not being sufficiently putrescent. Here the hide remains for some days, more or less, according to its texture, and from being hard and thick (the effect of the lime-water) it becomes very soft and supple. Where the hide is very thin and fine, extreme care is requisite in regulating this part of the process, for the putrescent dung is found so powerful an agent, that if the skin is kept in it only a few hours too long its texture is irrecoverably destroyed, and it is reduced to a gelatinous mass, which pulls to pieces with the slightest force. The hide is then thoroughly cleaned on the beam, and is fit for tanning.

The large thick ox or boar's hides intended for the toughest sole-leather, or where a very strong leather is required, are prepared in a different way. Being first cleaned in water, they are sometimes rolled up in heaps and put into a warm place where they speedily begin to putrify. The hair is then loosened, and may be scraped off sometimes with, and at other times without, the process of liming. The reason why the liming is generally omitted, is, that the lime, if retained in the skin, renders it too hard and liable to crack, and it is not so easy to wash it out from these as from the thinner hides. But on account of the thickness of the hide and the closeness of its texture it is not fitted to receive the tan liquor till its pores are more completely opened, and this is usually done by immersing it for several days in a vat containing a sour liquor, an impure acetous acid, formed from rye or barley flour strongly fermented. The acid generated in the process seems to be a principal agent in opening the texture of the skin, but this is doubtless assisted by the continuance of the fermentation, of which the skin itself partakes. This process is called raising, and it always immediately precedes that of tanning. Here also much care is required not to weaken the texture of the skin too much, for if kept too long in this process it would be corroded and spoiled. The hide comes out of this bath considerably swelled and softened.

Instead of this part of the process, which is often difficult to manage properly on account of the effect of the weather and other external causes on the necessary fermentation, Dr. Macbride has proposed the use of sulphuric acid extremely diluted, and this appears now to be pretty generally adopted. The proportions employed are about a wine pint of oil of vitriol to fifty gallons of water. Though the vitriolic bath is found to have as good an effect as the rye and barley sourings in preparing the hides for the tan, the action of the two substances seems to be considerably different. In the latter the acetous acid is doubtless the chief agent, but the fermentation still continues as is proved by the readiness with which the skins are rotted if this is too high or too long continued. The skin also after raising in this way is thickened and softened But the vitriolic bath is incompatible with any fermentation, and most powerfully checks this process, and hence the skin is not readily spoiled by very long immersion, and it comes out thickened and hardened. It should seem however that each method answers perfectly well.

The next process is that of tanning, which is essentially the same for all skins, however previously prepared, and is founded on the following chemical facts. A great variety of vegetable substances, that is all those that give an astringent taste when chewed (such as the bark of oak, willow, alder, and many other trees, the gall-nut, tea-leaves, &c. &c.) when macerated in water, hot or cold, yield to this menstruum a substance eminently astringent, of a greyish-white when pure, which is called tannin or tan, whose properties will be more fully described under that article. When any kind of skin is soaked in an infusion of tan it gradually absorbs it or extracts is from the water in which the tan is dissolved, and the skin thereby becomes of a firmer texture, sensibly heavier, no longer capable of putrefaction or any spontaneous change, less easily pervious to water, and no longer soluble in this fluid even at a boiling heat, which all untanned skin is,

whatever be its previous preparation. The art of tanning therefore essentially consists in nothing more than immersing skin for a sufficient length of time in an infusion of tan from vegetable bark or other sources till it is completely saturated with this principle. Hence the art of preserving the hides of animals by this method is one of the most antient and universal of all manufactures, no apparatus whatever being required to perform it, except a pit or hole of water in which the tanning vegetable may be put, and the skin thrown in along with it. And even in the most careful and improved methods of tanning, almost equal simplicity is observed in the operation, except that some art is used in regulating the strength of the tan-infusion, and some little manipulation in stirring the hides to give every part an opportunity of being thoroughly and equally soaked.

The substance used for tanning in this country is almost invariably oak-bark. The timber being felled in spring (when the sap has risen) the bark is stripped off and piled in large stacks, protected from the wet by a shed, but open at the sides to admit a free circulation of air through it. The bark, before using, is ground into coarse powder, and is thrown into pits with water, by which an infusion of the tan and other soluble parts is made, which is called, technically, ooze. The hides previously prepared in one or other of the ways above mentioned are then put first into small pits with a very weak ooze, where they are allowed to macerate for some weeks, with frequent stirring or handling as it is called. The strength of the different oozes is increased gradually, after which the half-tanned hides (if of the thick kind intended for sole-leather, and which require very complete tanning) are put into larger pits with alternate layers of ground bark, in substance, till the pit is filled; over which a heading of bark is also laid, and the interstices filled up with a weak ooze to the brim. The hides thus perpared are exposed to the full action of an ooze nearly saturated with tan, and supplied with more of this principle from the bark in substance, in proportion as the skin absorbs that portion already dissolved, till the tanning is judged to be complete. This, for the heaviest kind of leather, requires never less than fifteen months. Skin is known to be fully tanned by cutting a small piece off the edge of the hide, and observing the change of colour. As far as the tan has fully penetrated, the colour is of a nutmeg-brown, but the rest is white; and therefore, before the process is complete, the upper and under sides are brown, and a white line or streak is seen in the middle.

Lastly, when fully tanned, the hide is taken out to drain, and stretched upon a convex piece of wood called an horse, on which it is thoroughly smoothed, and beaten with a heavy steel pin, or sometimes passed between iron cylinders, to make it more solid, and at the same time supple; after which it is taken to the drying-house, a covered building with apertures for the free admission of air, where it remains till perfectly dry.

The common calves-skins require, for the whole process of conversion into leather in this way, from two to four months, the thick sole-leather hides from fifteen to eighteen or twenty months, and a boar's shield can hardly be finished in less than two years. Leather gains in weight and improves in quality the longer it is suffered to remain in the ooze (within certain limits); and, as it is sold by weight, this is also sometimes an object to the tanners, though counterbalanced to a great degree by the length of time that must elapse before his capital is returned.

The art is indebted to M. Seguin, a tanner of extensive business in France, for the first accurate explanation of the rationale of the process of tanning. According to the ancient idea of this process, the effect of the infusion of astringent vegetables was supposed to be little else than mechanical; and that it acted in *constringing* or *condensing* the fibres of the dead skin, as it corrugates the skin of the palate when tasted, and hence rendered it nearly impervious to moisture, and unsusceptible of putrefaction. This explanation however, did not accord with the actual increase of weight which the skin acquires by tanning; and which amounts, on an average, to an increase of from one-third to one-fourth of the weight of the skin when dry. M. Seguin, reasoning from the circumstance, that skin before tanning, is completely resolved by water into a liquid jelly, but is insoluble after tanning, was led to the simple experiment of adding a solution of skin (or glue) to an infusion of oak-bark, and found an immediate precipitate of a thick, tough, extensible, dun-white matter, strongly smelling of tan, and insoluble in water at any heat, and which, when dry, becomes of a dark-brown colour and brittle.

This precipitate is an intimate combination of gelatin with that part of the vegetable infusion which gives the tanning property, and being altogether a peculiar substance, is denominated *tannin* or *tan*, whose properties will be more fully described under that article. This precipi-

tate therefore, hardly differs from tanned leather in any thing but in wanting the fibrous organized texture, and what other principles the skin may have absorbed from the bark-infusion during the maceration of several months, which a sudden precipitation would not effect. Tanning, therefore, consists chiefly in a slow and most intimate combination of vegetable tan, with the fibre of the skin, which continues till the latter is saturated through its whole thickness.

But oak-bark contains other soluble matter, which certainly also enters the texture of the skin along with the tan, and most intimately combines with it; for skin, when it has undergone the previous preparation already mentioned, appears to be able to absorb, and when absorbed, to retain a great variety of vegetable and animal substances. The infusion of oak-bark contains, besides tan, the gallic acid, and an extractive matter, all of which contribute to the process, and form a part of the tanned leather. That the gallic acid is absorbed, is proved by the instant blackness which the leather assumes, when merely rubbed with a solution of any salt of iron. The extract appears to be that which gives the leather its colour, and some degree of flexibility; and from the excellent observations of Mr. Davy on the process of tanning, it seems probable, that the quantity of tan absorbed, is a good deal regulated by the quantity of extract present, being in general (the time of immersion and strength of the tan-infusion being nearly equal) in inverse proportion to the quantity of extract, or of mucilage, present in the infusion. This is found by comparing the actual weight acquired by leather, by quick tanning in infusions of different tanning materials, the composition of which has been previously ascertained by chemical analysis. The difficulty in experiments of this kind, of obtaining tolerable accuracy, is, however, very great, much greater than in the analysis of metals or minerals, on account of the great want of characteristic marks of distinction between vegetable matters, when a little changed by chemical union with other bodies, and the readiness with which their characters are irrevocably lost, by the common action of re-agents.

The strength of the tanning infusion also most materially affects the quality of the leather, and the weight which the skin gains during the process. As tan is more soluble than extract, a solution made hastily, and with a large portion of the material, will be nearly saturated with tan, and contain comparatively but little extract; and, on the other hand, the residue of the above infusion, macerated for a longer time in fresh water, will give a solution in which there is but little tan, but a large quantity of extract. Now it would seem, that skin has the power of fixing a larger quantity of tan than of any other material, particularly that of extract; so that if already nearly saturated with extract, it will of course, absorb much less tan than before, and therefore the entire increase of weight will be much less in this way than with tan alone. The quality also of the leather, will of course, be probably different, when compounded of skin and tan, with very little other ingredients, than when it is a compound of skin and tan, with a larger portion of extract; and, in particular, the former seems to be more brittle, and less durable than the latter, as far as experiments have hitherto been made. The mere duration of the process also, as regulated solely by the strength of the infusion, that is, where precisely the same infusion is used, but more or less diluted, may probably considerably affect the quality of the leather; for, when the process goes on very rapidly, it is possible that the outer part of the skin may be tanned strongly, before the inner part is penetrated with the liquor; and, as tanning gives a closeness of texture, and difficult permeability to liquids, it may happen, that this very circumstance may prevent that uniformity of saturation with tan, which would seem desirable.

The precipitate made by a solution of gelatin, dropped into an infusion of any tanning vegetable matter, appeared by Mr. Davy's experiments, to be tolerably uniform in its composition, whatever be the other constituents of the vegetable infusion. Thus, when galls were used, the precipitate contained about 46 of tan, and 54 of gelatin; with catechu, it contained 41 per cent. of tan; with oak bark, 41 per cent. and with the Leicester willow, 43. But real skin will never acquire such an increase of weight as the solution of gelatin, either because other substances enter the composition of leather, or because the texture of the skin will not allow it to condense and chemically unite with so much tan as the same skin when dissolved in the form of glue; for glue (as mentioned under the article GELATIN) is only a solution of the refuse part of skin. Thus it was found, that a piece of skin compleatly tanned by three week's immersion in a strong infusion of galls, only gained weight in the proportion of 39 to 61 of skin; and this was even the greatest increase of weight observed, (being much

more than that of common leather,) and in consequence, made a much harder and more brittle leather.

With regard to the effect produced by the time of immersion, it was found in different experiments, that skin, apparently equally well tanned in each case, absorbed much more tan by rapid, than by slow tanning; 100 parts of leather prepared in 2 weeks, containing 73 of skin and 27 of tan, and other materials, absorbed from the oak bark infusion, and the same quantity of leather prepared in 12 weeks (the infusion being proportionably weaker) containing 85 of skin, and 15 of tan, and other vegetable matter. A similar difference was found when infusion of willow bark was employed.

The supposed improvement in the process of tanning, practised, and actually proposed by M. Seguin, may here be shortly mentioned. This ingenious artist, wishing to abridge the enormous time employed in common tanning (and consequent expence) and considering the tan as nearly the only active principle in this process, adopted the plan of using solutions of tan, instead of the mixture of bark and ooze usually employed, and of several and known degrees of strength, in which the skin might be rapidly passed from the weakest to the strongest, by a more regulated gradation than is usually done. For this purpose he had a series of vats, containing the oak-bark, and began by pouring water on one of them, and, after a short time, drawing it off clear through a hole at the bottom. This first ooze was then poured on the bark of the second vat, and drawn off as before, by which it became sensibly stronger of tan. This liquor again was used to the third vat, and again to a fourth, according to the number, till it became quite saturated with tan. In the mean time, fresh water was poured on the bark of the different vats in the same order, which produced a second ooze, still very strong, but inferior to the first: and thus, three or four, or more different oozes were obtained, all differing in strength, and which was the tanning liquor employed. The skins then being previously prepared in the way already described, were passed successively through the different oozes, beginning with the weakest and ascending to the strongest, till they were compleatly tanned, which was known by the disappearance of the white line in the middle of the skin when cut through.

It appears, beyond a doubt, that the process of tanning, is most materially shortened by this method of M. Seguin, and that very perfect leather is produced; but, though now known for several years it does not appear to be adopted to any extent in this country, where leather is manufactured in vast quantities, both for home consumption and for exportation to many parts of Europe, in which English leather is in the highest repute. From the way in which the oozes are made, according to M. Seguin, they must of necessity, contain much more tan in proportion to the extract and other vegetable matter, than where the bark itself is suffered to remain in substance along with the ooze and skin for many months, as the tan is much the most soluble of all the substances that are to be extracted by water; so that bark may readily be exhausted of tan, long before the extract, resin, gallic acid, and other materials are got out. It is said, that the leather prepared in this new method, is less durable and more brittle than in the old way.

The only real improvement, of late, adopted in this part of the process, is to use some of the oozes warm, by which the skin is sooner penetrated with the ooze, and a saving of time made of some consequence.

Dr. Macbride proposes lime-water to be used, instead of common water, for the extraction of the tan from the oak-bark; but this seems to be mischievous, as the only assignable effect of the lime would be, to contract a firm union with a portion of the gallic acid and the tan, the result of which would be an insoluble calcareous substance, utterly unfit for any purposes of tanning.

Of Tawing, Leather-dressing and dyeing, and other processes.

The dressing and preparing of the skins of lambs, sheep, goats, and other thin hides, though in many particulars closely resembling the method used with the thick cow and ox hides, forms usually a totally distinct branch of business; and is one in which a good deal of practical skill and nicety of manipulation is required, to succeed perfectly. The processes are very various according to the article required; and, this branch of the manufacture supplies the immense demand of white and dyed leather for gloves, the (so called) morocco leather of different colours and qualities for coach linings, book-binding, pocket-books, and thin leather, for an infinite number of smaller purposes. Of these, the white leather alone is not tanned but finished by the process of tawing, but the coloured leather receives always a tanning (generally by sumach) independent of the other dyeing materials. The previous preparation of each, or that in which the skin is tho-

roughly cleansed and reduced to the state of simple membrane, in which it is called *pelt*, is essentially the same, whether for tawing or dyeing. It is thus performed at the best manufactories at Bermondsey, near London, a place long celebrated for all branches of the leather business.

By far the greater number of the skins are imported; if lambs they are thus prepared: the skins are first soaked for a time in water, to cleanse them from any loose dirt and blood, and put upon the beam commonly used for the purpose, which is a half cylinder of wood covered with strong leather, and scraped on the flesh side with the semicircular blunt knife with two handles used in this operation. They are then hung up in considerable numbers in a small close room heated by flues, where they remain to putrefy for a given time, as is easily perceived by the strong ammoniacal odour which issues from them when the door is opened. During this process a thick filthy slime works up to the surface of the skin, by which the regularity of the process is judged of; and the wool is loosened so that it readily comes off with a slight pull. Each skin is then returned to the beam, the wool taken off and preserved, and all the slime worked off with the knife, and the rough edges pared away. The skin is then put into a pit filled with lime water and kept there from two to six weeks more or less according to the nature of the skin, which has the effect of checking the further putrefaction, and produces a very remarkable hardening and thickening of its substance, and probably also it detaches a further portion of the slime. The skin is again well worked upon the beam, and much of its substance pared down, and all inequalities smoothed with the knife. Much pains and judgment are required in these operations, on the one hand not to endanger the substance of the skin by the putrefaction (which if carried on too long would soon reduce it to an incohesive pulp) and on the other hand to work out every particle of the slime, the least of which if retained will prevent the skin from dressing well in the subsequent processes, and from taking the dye uniformly and well. The skin is then again softened and freed from the lime by being thrown into a vat of bran and water, and kept there for some weeks in a state of gentle fermentation, being occasionally returned to the beam. All the thickening produced by the lime is thus removed, and the skin is now as highly purified as possible, and is a thin extensive white membrane called in this state a pelt, and is now fit for any subsequent operation of tawing or dyeing, or oil dressing, or shammoying.

The method of bringing kid and goat's skins to the state of pelt is nearly the same as for lambs, except that the liming is used before the hair is taken off, the hair being of no great importance, and only sold to the plaisterers, but the lamb's wool, which is more valuable, would be injured by the lime. Kids' skins will take a longer time in tanning than lambs'.

If the pelts are to be tawed, they are then put into a solution of alum and salt in warm water, in the proportion of about three pounds of alum and four pounds of salt to every 120 middle-sized skins, and worked about therein till they have absorbed a sufficient quantity. This again gives the skin a remarkable degree of thickness and toughness.

The skins are then taken out and washed in water, and then again put into a vat of bran and water and allowed to ferment for a time, till much of the alum and salt is got out and the unusual thickening produced by it is for the most part reduced. They are then taken to a lofty room with a stove in the middle, and stretched on hooks and kept there till fully dry. The skins are then converted into a tough, flexible, and quite white leather; but to give them a glossy finish, and to take off the harshness of feel still remaining, they are again soaked in water to extract more of the salt, and put into a large pail containing the yolks of eggs beat up with water. Here the skins are trodden for a long time, by which they so completely imbibe the substance of the egg that the liquor above them is rendered almost perfectly limpid, after which they are hung up in a loft to dry and be finished by glossing with a warm iron. There are other smaller manipulations, which need not be here mentioned.

The essential difference therefore between tanning and tawing is, that in the former case the pelt is combined with tan and other vegetable matter, and in the latter with something that it imbibes from the alum and salt (possibly alumine) and which certainly is never again extracted by the subsequent washing and branning.

The (so called) Morocco leather, prepared from sheep-skins chiefly, and used so largely for coach-linings, pocket-books, and the best kind of book-binding, is thus made. The skin, cleansed and worked in the way already described, is taken from the lime-water, and the thickening thereby occasioned is brought down, not by bran liquor as in tawing, but by a bath of dogs' or pigeons' dung diffused in wa-

ter, where it remains till sufficiently suppled, and till the lime is quite got out and it becomes a perfectly white clean pelt. If intended to be dyed red it is then sewed up very tight in the form of a sack with the grain side outwards (the dye only being required on this side) and is immersed in a cochineal bath of a warmth just equal to what the hand can support, and is worked about for a sufficient time till it is uniformly dyed, a process that demands much skill and experience. The sack is then put into a large vat containing sumach infused in warm water, and kept for some hours till it is sufficiently tanned.

The skins intended to be blacked are merely sumached without any previous dyeing. After some further preparation the colour of the fine red skins being finished with a weak bath of saffron, the skins when dry are grained and polished in the following way. They are stretched very tight upon a smooth inclined board, and rubbed over with a little oil to supple them. Those intended for black leather are previously rubbed over with an iron liquor, by means of a stiff brush, which, uniting with the gallic acid of the sumach, instantly strikes a deep and uniform black. They are then rubbed by hand with a ball of glass cut into a polygonal surface, with much manual labour, which polishes them and makes them very firm and compact. Lastly, the graining or ribbed surface by which this kind of leather is distinguished is given by rubbing the leather very strongly with a ball of box-wood, round the centre of which a number of small equidistant parallel grooves are cut in, forming an equal number of narrow ridges, the friction of which gives the leather the desired inequality of surface.

The common mode of currying leather for shoes, boots, &c. consists in first softening the hides as they come from the tan-pit, partly by soaking in water, partly by mechanical means, aud then impregnating it with some kind of oil, by which means it is rendered much more impervious by moisture, and proper to protect the feet from the inclemency of the seasons. The process in a few words is the following: the hide is first soaked thoroughly in water, then placed on a polished wooden beam with the flesh side outwards, and pared with a broad sharp knife till all the inequalities are removed and it is reduced to the required thinness. It is then again washed and rubbed with a polished stone, and while still wet it is besmeared with curriers oil, generally fish-oil, or a mixture of this and tallow. When hung up to dry the moisture evaporates, and the oil, which cannot be dissipated by mere exposure, gradually takes the place of the moisture, and penetrates deeply into the pores of the leather. It is then dried either in the sun or in a stoved room.

Blackening the leather is also a part of the curriers business, which is done on the grain side, simply by rubbing with an iron liquor, but on the flesh side with a mixture of lamp-black and oil.

Shammoyed leather is generally sheep or does skin, prepared in the way already mentioned by dressing, liming, &c. and dyed if necessary, and then finished in oil. This forms the common wash-leather, breeches leather, &c. and is the only kind which, when dyed, will bear washing without the colour being materially injured.

Common boot-leather, as usually prepared, is still in some degree pervious to water by long exposure to wet, and therefore fishermen, wild-fowl shooters, and those whose employment or amusement leads them to be long on wet ground, usually prepare their boots with an additional dressing of some oily or resinous matter.

The punt-shooters in Cambridgeshire and the adjoining fenny parts of England, use the following mixture with very good effect. Melt together in an earthen pipkin half a pound of tallow, 4 ounces of hog's lard, 2 ounces of turpentine, and as much bees-wax: make the boots thoroughly dry and warm, and rub in this mixture well with a little tow as hot as the hand can bear, or else hold the boots over a very gentle fire till the leather has thoroughly imbibed it. Another mixture for the same purpose, and used by fishermen, is: bees-wax, Burgundy pitch, and turpentine, of each 2 ounces; tallow, 4 ounces: or half a pound of bees-wax, a quarter of a pound of rosin, and the like quantity of beef-suet. In all cases the boots must be quite dry, and the mixture applied very warm.

It only remains on the subject of leather to notice very shortly some of the most remarkable kinds of leather prepared in foreign countries, for the general methods of making leather resemble each other very closely in every part of the globe.

The process for the real Morocco leather, as prepared from goat-skins at Fez and Tetuan, is thus described by M. Broussonet. The skins are first cleansed, the hair taken off, limed and reduced with bran nearly in the way already described for the English Morocco leather. After coming from the bran they are thrown into a second bath made of white figs,

mixed with water, which is thereby rendered slimy and fermentable. In this bath the skins remain four or five days, when they are thoroughly salted with sal-gem (or rock salt) alone (and not with salt and alum) after which they are fit to receive the dye; which, for the red, is cochineal and alum, and for the yellow, pomegranate bark and alum. The skins are then tanned, dressed, suppled with a little oil, and dried.

Much excellent leather of every kind is prepared in different parts of the Russian empire. The preparation of the fine Russia leather, so well known for its quality and for its peculiar smell, is described at large in Mr. Tooke's "View of the Russian Empire," to which we must refer the reader for the minuter particulars. In general it may be stated, that the hides are first put into a weak alkaline lye to loosen the hair, and then scraped on a beam, then (if calves) are reduced by dogs dung, and a sour oatmeal drench, then tanned with great care and frequent handling. The bark used here is seldom oak, but, where it can be got, the bark of the black willow, or if this cannot be had, birch-bark. They are then dyed either red or black, these being the two colours the most esteemed. For the red the hide is first soaked in alum and then dyed with brazil wood. The black is given as usual with an iron liquor. The leather is then smeared with birch tar, which gives the peculiar smell so much prized (and which when used for book-binding has the valuable property of protecting the book from worms,) and is finished by various other manipulations. The streaked or barred surface is given to the leather by a very heavy steel cylinder wound round with wires.

A valuable Saffian or dyed Maroquin leather, almost equal to that of Turkey, is prepared largely at Astracan and other parts of Asiatic Russia. Only bucks and goats skins are used for this purpose. The favourite colours are red and yellow. The general method of preparing the pelt is the same as in this country for the dyed Morocco leather, that is by lime, dog's dung, and bran. Honey is also used after the branning. The honey is dissolved in warm water, and some of this liquor is poured on each skin spread out on wooden trays till it has imbibed the whole of the honey, after which it is let to ferment for about three days, and then salted in a strong brine and hung up to dry. The skin is then ready to receive the dye, which, for red, is made with cochineal and the salsola ericoides, an alkaline plant growing plentifully on the Tartarian salt desarts, and the colour is finished with alum. When dyed, the skins are tanned with sumach. To the very finest reds a quantity of sorrel is used with the cochineal bath, and the subsequent tanning is given with galls instead of sumach, which renders the colour as durable as the leather itself. The roughness, always observed on the surface of the skin, is given by a heavy kind of iron rake with blunt points. The yellow saffians are dyed with the berries of a species of rhamnus (the Avignon berry would answer the same purpose, and is used in other countries) or with the flowers of the wild camomile.

That singular and valuable leather called Shagreen, is a manufacture almost peculiar to Astracan, where it is prepared by the Tartars and Armenians. For making shagreen only horses' or asses' hides are taken, and it is only a small part from the crupper along the back that can be used for this purpose. This is cut off immediately above the tail in a semicircular form, about 34 inches upon the crupper and 28 along the back. These pieces are first soaked in water till the hair is loose and is scraped off, and the skin, again soaked, is scraped so thin as not to exceed a wetted hog's bladder in thickness, and till all the extraneous matter is got out, and only a clean membranous pelt remains. The piece is then stretched tight on a frame, and kept occasionally wetted that no part may shrink unequally. The frames are then laid on a floor with the flesh side of the skin undermost, and the grain side is strewed over with the smooth black hard seeds of the alabuta or goosefoot (Chenopodium album) and a felt is then laid upon them, and the seeds trodden in deeply into the soft moist skin. The use of this is to give the peculiar mottled surface for which shagreen is distinguished. The frames with the seeds still sticking to the skin are then dried slowly in the shade till the seeds will shake off without any violence, and the skin is left, a hard horny substance with the grain side deeply indented. It is then laid on a solid block covered with wool, and strongly rasped with two or three iron instruments (the particular form of which need not be here described) till the whole of the grain side is shaved, so that the impression of the seeds is very slight and uniform. The skins are then softened, first with water, and then with a warm alkaline lye, and are heaped warm and wet on each other, by which means the parts indented bv the impression regain much of their elasticity, and having lost none of their substance by paring, rise up

fully to the level of the shaved places, and thus form the grain or granular texture peculiar to the shagreen. The skin is then salted and dyed.

The beautiful green dye is given by soaking the inner or flesh side of the skin with a saturated solution of sal-ammoniac, strewing it over with copper filings, rolling it up with the flesh side inwards, and pressing each skin with a considerable weight for about twenty-four hours, in which time the sal-ammoniac dissolves enough of the copper to penetrate the skin with an agreeable sea-green colour. This is repeated a second time to give the colour more body.

Blue shagreen is dyed with indigo dissolved in an impure soda by means of lime and honey. Black shagreen is dyed with galls and vitriol. The skins are finished with oil or suet. See TANNING.

LEATHER, boots, bootees, and shoes of iron bound.

Mr. Bedford, of this city, has obtained a patent, for a new mode of making shoes, boots, &c. which appears to be preferable, in many respects, to those made in the ordinary way. The patentee, in his advertisement, gives the following observations. He remarks, that "shoemakers, by his improvement, are able to make four times the quantity of shoes that can be made in the common way with the same number of hands; for example, the usual work of three men, is only three pair of common shoes per day; whereas in the improved way, three men wirh the assistance of a boy, can make from twelve to fifteen pair per day. Thus the advantages, resulting from the improvement, are evidently of the most essential importance. In the first place, three-fourths of the labour is saved; in the second place, half the leather is saved, for one pair of shoes made in this way, will wear as long as two pair made in the usual way; and in the third place, there is a saving of flax, at the rate of one pound to twenty pair of shoes; they are also much more water proof than the others, and easier mended."

Leather, how rendered water proof—Mr. Mollersten has obtained a patent for a composition to render leather water proof, which he extends also to woollen cloth, linen, and other stuffs. He observes, that it will render them not only impenetrable to hot and corroding liquors, but will give them a fine gloss, and preserve them from decay.

To prepare the composition of a black colour, Mr. Mollersten gives the following directions:

Take two gallons of linseed oil, one gallon of whale oil, half a pound of horse grease, mingle them with four pounds of finely ground Prussian blue, and four pounds of lamp black, and afterwards boil them over a strong fire; to which add, one pound of fine ground benzoin gum, previously well mingled in one gallon of linseed oil, of which one half gallon is to be put in the above, when the composition has boiled half an hour, and the remainder when the boiling is finished. This composition is sufficiently boiled when it gets so thick that no drops fall from any thing dipped into it; and it is afterwards fit for use when cold.

For making the composition of other colours. The genuine linseed oil must be well bleached: to two gallons of which put half a gallon of spermaceti oil, and half a pound of Prussian blue, place them in a glass vessel in a strong sun (the effect may be increased by burning glasses if necessary) and when they have attained the same consistency as the black composition, after having boiled one half hour, take one pound of benzoin gum mixed with one gallon of linseed oil bleached, add one half of it to them and place the same in the sun, as before; and, when it has again attained the same consistency as the black composition, add the remaining half of the gum and oil.

Mr. Mollersten recommends that the colours used should be at least one half of metallic compositions, as he is not certain that colours composed of animal substances only will answer the purpose: he also observes, that the Prussian blue mixed with the other colours renders the substances on which they are put capable of resisting hot and corrosive liquors, though without it they will resist wet equally well.

Mr. Mollersten directs the composition to be laid very thin at first, on the substances to which it is to be applied, and that scraping irons be used for this purpose.

The substances are then to be stretched on a board or frame over blanketing, and put into an oven to dry the composition, and the operation is to be repeated till the substances have attained the proper gloss and smoothness; besides the scrapers, pumice stone is to be used in the intervals of drying, to make the surfaces smooth and even: from four to six repetitions of the lackering and drying will generally complete the process.

The Editors of the Retrospect of Discoveries, observe, that one of the directions for boiling the composition should not be followed too exactly, or the whole composition will probably be spoiled, that is, "to boil it till no drops fall from any

thing dipped into it." This is one of those extremely vague rules which those who are well acquainted with a process frequently give, from not considering that those they desire to instruct are not sufficiently acquainted with such operations to know that they mean by such phrases any thing but the literal sense. The direction would probably be nearer the truth if it was, that the matter should be boiled till it adhered to any thing dipped into it; or till the whole of the matter adhering to any thing dipped into it did not again fall off in drops.

This subject however will be again considered, in which we will notice the patents of several other persons, for the same purpose.

LEAVEN, or sour dough, is a fermented mixture of flour and water, which is effected generally with yeast, and is used to ferment a large quantity of paste in lieu of yeast. It is, however, a very imperfect substitute. Mr. Tillyer has prepared the following substitute, which may be classed under this head, as a substitute for yeast, which we have extracted from the *Repertory of Arts*. To make an yeast gallon of this composition, boil in common water eight pounds of potatoes, as for eating; bruise them perfectly smooth, and mix with them whilst warm, two ounces of honey, or any other sweet substance, and one quart of common yeast. And, for making bread, mix three beer pints of the above composition with a bushel of flour, using warm water in making the bread; the water to be warmer in winter, and the composition to be used in a few hours after it is made; and as soon as the sponge (the mixture of the composition with the flour) begins to fall the first time, the bread should be made and put in the oven. See YEAST.

LEAVES of Plants. Lewis found, that the green colour of the leaves of plants, is extracted by alcohol, and by oils. The spirituous tinctures are generally of a fine deep green, even when the leaves are dull coloured, yellowish, or hoary. These colours are seldom lasting in the liquor. Alkalis heighten both the tinctures and the green juices. Acids weaken, destroy, and change it to a brownish. Lime-water improves both the colour and durability. By means of lime, not inelegant green lakes are procurable from the leaves of acanthus, lily of the valley, and several other plants.

Few plants communicate any part of their green colour to water, and perhaps none that give a green of any considerable intensity. It is said, however, that the leaves of some plants give a green dye to woollen, without the addition of any other colouring matter; particularly those of the wild chervil, or cow-weed, the common rag-wort and devil's bit. Lewis gives the process from Linnæus, as practised by the peasants in Sweden, with the last. It consists in boiling the leaves with their woollen yarn for a short time, and leaving the whole together for a night, after which the yarn is taken out, hung in the steam of the liquid, and again made to boil over the fire. It is then wrung, the leaves are taken out of the liquor, a little fresh water added, and the wool frequently dipped therein till sufficiently dyed.

Many kinds of leaves afford a yellow dye to woollens, previously boiled with alum and tartar, weld in particular, which see. Indigo and woad afford blue. Lewis tried without success, to obtain blues by macerating the leaves of other plants in water.

It is said, that the leaves of the plant, which Dr. Barton discovered, the Woodhousia Tinctoria, found, I think, in Virginia, will yield a beautiful dye.

LEMONS. The citrus lima, or Lemon tree, has an upright smooth trunk, divided at the top into a branchy regular head; from twelve to fifteen feet high; large oval, spear-shaped, pointed, slightly sawed leaves, on lineal footstalks; and many flowers from the sides of the branches, succeeded by large oval fruit, prominent at the top. The varieties are: the Lemon tree with sour fruit; with sweetish fruit; with very large fruit called Imperial Lemon; with pear shaped fruit; with furrowed fruit; with clustered fruit; with childing fruit; with whitish fruit; with tricoloured striped fruit, &c.

The flowering and fruit setting season for the Lemon tree, is chiefly in June and July. It continues blowing and setting fruit, for three months, when a full crop is set. The fruit is of a green colour first, turning yellow as it grows ripe. Its shape is almost oval, and divided into several cells, in which are lodged hard seeds, surrounded by a thick fleshy substance, full of an acrid juice. The best Lemons should be large, weighty, and of a thin rind.

In the southern part of France, Spain, Portugal, and Italy, there are forests full of Lemon trees, and a considerable trade is carried on in transporting them to all the northern parts of Europe. They are for that purpose, wrapped up in soft paper, and packed in chests.

The Lemon yields a very agreeable acid juice, which, besides its common use, answers considerable purposes in medicine. The yellow peel of the Lemon is

an agreeable aromatic and excellent stomachic; it is also used by the confectioners to be candied. Considerable quantities of pickled Lemons are annually shipped from the Mediterranean for the Baltic. The true, unadulterated oil, obtained from Lemon peel, is very valuable.

LEMON JUICE. An agreeable acid, obtained from the lemon fruit, which, when fresh, is used as a cooling draught, mixed with water and sugar, under the name of lemonade: the same articles combined with spirit, as gin, whiskey, or brandy, form the beverage called punch. Without stating its use in medicine, when combined with different substances, we shall only remark, that it is an excellent antiseptic, and as such, is highly recommended by Dr. Pringle, for the sea scurvy. In order to preserve the juice, different methods have been recommended, some of which are given in the following article.

LEMON JUICE, the purification and preservation of.

With respect to the purification of the juice of lemon, which consists principally in separating the mucilaginous matter, with which it is intermixed, Mr. Scheele in particular has given considerable attention. He recommends, before bottling the juice, to boil it for some time, which will separate a large quantity of foreign matter in the form of scum; after removing which with a ladle, he then advises filling and immediately bottling the juice, taking care to screw the corks sufficiently tight. The object in thus separating the foreign matter, is to prevent the putrefactive change, and by keeping it well closed, to prevent the access of air. As the latter has a considerable tendency to change the qualities of lime or lemon juice, some recommend putting the juice in small bottles, and filling the rest of the bottle with sweet oil. Before using it, the oil may be readily removed by means of lint or cotton. This mode is highly recommended in the Domestic Cookery.

Of all the methods of preserving lemon-juice, that of concentrating it by frost appears to be the best, though in the warmer climates it cannot conveniently be practised. Lemon-juice, exposed to the air, in a temperature between 50° and 60°, deposits in a few hours a white semitransparent mucilaginous matter, which leaves the fluid, after decantation and filtration, much less alterable than before. This mucilage is not of a gummy nature, but resembles the gluten of wheat in its properties: it is not soluble in water when dried. More mucilage is separated from lemon-juice by standing in closed vessels. If this depurated lemon-juice be exposed to a degree of cold of about seven or eight degrees below the freezing point, the aqueous part will freeze, and the ice may be taken away as it forms; and if the process be continued until the ice begins to exhibit signs of acidity, the remaining acid will be found to be reduced to about one-eighth of its original quantity, at the same time that its acidity will be eight times as intense, as is proved by its requiring eight times the quantity of alkali to saturate an equal portion of it. This concentrated acid may be kept for use, or, if preferred, it may be made into a dry lemonade, by adding six times its weight of fine loaf sugar in powder.

The above processes may be used when the acid of lemons is wanted for domestic purposes, because they leave it in possession of the oils, or other principles, on which its flavour peculiarly depends; but in chemical researches, where the acid itself is required to be had in the utmost purity, a more elaborate process must be used.

LEMON, acid of. See Citric Acid.

LEMON ACID, (dry.) In consequence of the scarcity of fruit, the juice of the lime, or lemon, cannot at all times be obtained. N. S. Allison & Co. of Philadelphia, have therefore made a preparation, which is sold as *pure lemon acid*, which makes an agreeable drink, such as punch, lemonade, &c. We do not doubt but that it is the concrete acid, and will answer all the purposes of the fruit, or juice of the lemon. Whether it be the fact or not, this much is certain, that it is calculated, from its flavour, acidity, &c. to supercede the juice, and therefore, when the juice cannot be obtained, must be considered as a valuable acquisition. In their advertisement they observe, that

"This acid retains all the grateful flavour of the fresh lemon, makes most excellent punch, lemonade, shrub, &c. and instantly dissolves in warm or cold water; is also adapted for every purpose in cookery, where the lemon is required, such as sauces, jellies, &c.

"The convenience of this acid for taverns and public places of amusement, is sufficiently obvious, as it will make punch, lemonade, &c. at any time of the year, equally rich as with the fruit, and always cheaper. For balls and assemblies this elegant preparation is particularly desirable; as lemonade, &c. may be made in the most easy and expeditious manner. It will also impart a pleasant flavour to a glass of seltzer, or other mineral waters.

"It is particularly recommended to officers and gentlemen travelling, to captains

of ships and others going long voyages; it is perfectly dry and portable, and will keep for any length of time, in every climate.

"It is warranted to contain no extraneous matter, being nothing but the pure acid of lemons."

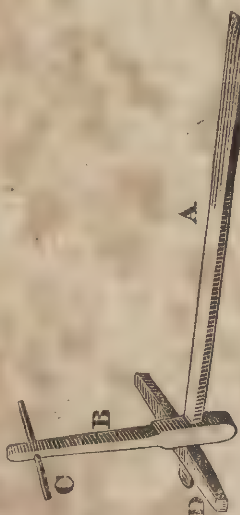
LEMON, essential salt of. This preparation, which is sold in the shops to make punch, and remove ink stains and iron moulds, is nothing more than citric acid, combined with a little of the essential oil of lemon.

Very frequently, supertartrate of potash (cream of tartar) or superoxitate of potash (salt of sorrel) is sold for it. See Citric Acid.

LETHARGY, in Farriery. See Farriery.

LEES of soap. See Soap.

LEVER, cross bar, invented by Mr. Windham, of England, on whom the Society for the Encouragement of Arts, &c. in 1796, conferred their silver medal.



A, is the lever.

B, an upright piece of wood, to be affixed to the lever; care being taken to place the side marked with this letter opposite to that marked A on the lever; by which means it inclines backwards, and thus increases the power.

C, is a cross-bar, being the hand by which the workmen exert their strength.

D, is another cross-bar, to be placed at the bottom, behind the upright piece of wood, on which the labourers are to stand, and through which the end of the lever passes These additions are so constructed, that they may be occasionally fixed and removed; because they are to be employed only, when the strength of the rock, or each, requires an increase of power.

Should the rock be elevated so considerably above the ground, as to endanger the men by its fall, when the separation takes place, the lever may be reversed; so that the labourers will stand upon the bar intended for the application of their hands, in common cases; and thus all danger will be effectually prevented.

Various other levers have been contrived; which will be noticed in Mechanics.

LEVIGATION. The mechanical process of grinding the parts of bodies to a fine paste, by rubbing the flat face of a stone called the muller upon a table or slab called the stone. Some fluid is always added in this process. The advantage of levigation with a stone and muller, beyond that of triturating in a mortar, is, that the materials can more easily be scraped together, and subjected to the action of the muller, than in the other case to that of the pestle; and, from the flatness of the two surfaces, they cannot elude the pressure.

LEY, a solution of potash, made caustic by means of lime. The process of extracting the alkali from wood ashes, and the setting of the ley tub, are too well known to require description. The use of lime is intended to render the liquor caustic, which it does by abstracting the carbonic acid from the alkali. See Soap.

LICHEN-LIVERWORT. Several species of this genus are useful in the arts, particularly dyeing, or as food or medicine. Under the word Archil we have already noticed one. To wool, previously prepared with a bath of lycopodium complanatum, l. clavatum, or l. alpinum, the lichen Westringii is said to give a fine orange, superior to that of annotto. The lichen cinereus does the same. The chlorinus gives a bright yellow, and the vulpinus a lemon colour. Brasil gives to wool thus dyed with the l. Westringii a very deep blue black; to that with the chlorinus a fine green black, or raven's wing colour; and to that with the vulpinus a bluish green. The lichen parellus, from which archil has been said by some to be prepared, affords only a blue, which is so fugitive as to be useless.

Lord Dundonald has lately taken out a patent for the use of lichen as a substitute for gum. Lichens that grow on trees

and shrubs afford this gum, and apparently different species of them. The lichen is scalded two or three times with boiling water, to remove the outer skin and resinous matter, washed in cold water, and then left ten or twelve hours on a stone or brick floor; after which the gum is extracted by boiling some hours in water, with about half or three quarters of an ounce of alkali to each pound of lichen. According to the report, 1lb. of dry lichen will do as much work in calico-printing as $1\frac{1}{2}$lb. of gum senegal.

LIGNEOUS ACID. See Acid.

LIGHT RED. See Colour Making.

LIGHTNING RODS. Since the discoveries of Dr. Franklin, and the identity of the electric fluid and lightning being established, means have been recommended, first by Dr. Franklin, and afterwards by others, for securing houses from the effects of lightning. These are called conducting or lightning rods.

A great dispute has been carried on among electricians concerning the termination of conducting rods, for preserving buildings from lightning; some warmly contending, that they should be terminated by knobs or balls; others as strenuously contending, that they should be pointed.

Ever since the identity of electricity and lightning has been proved, conductors of some kind have been generally allowed to be necessary for the safety of buildings in thunder storms, as they afford a ready passage for the union of the contrary electricities. Electricians seem to have forgotten, that neither lightning nor electricity ever strikes a body, merely for the sake of the body, but because that body is a means of restoring the disturbed equilibrium.

When a quantity of electricity is excited by means of an electric machine, a body communicating with the earth, will receive a strong spark from the prime conductor; it receives this spark, not because it is capable of containing all the electricity of the cylinder and conductor, but because, the natural situation of the fluid being disturbed by the motion of the machine, the natural powers make an effort to restore the equilibrium. No sooner, then, is a conducting body, communicating with the earth, presented to the prime conductor, than the whole effort of the electricity is directed against that body; not merely because it is a conductor, but because it affords a place, by which the natural powers can more readily unite, and which they would do by other means, though that body were not to be presented. That this is the case, we may easily see, by presenting the same conducting substance in an insulated state to the prime conductor of the machine, when we shall find only a small spark will be produced. In like manner, when lightning strikes a tree, a house, or a conducting rod, it is not because these objects are high, but because they are situate in that place, where, from a variety of causes, the impetus of the two powers can be lessened by uniting with each other.

From hence we perceive the fallacity of that kind of reasoning, which is generally employed concerning the use of thunder rods.

Because a point presented to an electrified body, in our experiments, draws off the electricity in a silent manner, Dr. Franklin and his followers have concluded, that a pointed conductor will do the same thing to a thunder cloud, and thus prevent any kind of danger from a stroke of lightning.

But, for this very reason, Mr. Wilson and his party have determined, that the use of pointed conductors is utterly unsafe; they justly consider the Franklinian idea of exhausting the clouds of their electricity, to be not less absurd, than it would be to clear away an inundation with a shovel, or exhaust the atmosphere with an air-pump. They bring many instances, where a point will receive a full stroke, and assert, that it solicits a discharge; and that, being often unable to conduct the whole electricity of the atmosphere, it is impossible for us to know whether the discharge it solicits, may not be too great for the conductor to bear; and, consequently, all the mischiefs arising from thunder storms may be expected, with this mortifying circumstance, that this very conductor has probably solicited the fatal stroke.

We must also further observe, that the Franklinians, still make their pointed conductors of too much consequence; for it is now well known, that points have no influence at all, unless they be immerged in the electrified atmosphere. If a pointed body do not communicate with the earth, but the communication be interrupted by a short interval, it will receive a full spark. It will also receive a full spark, if it be suddenly brought sufficiently near a strongly electrified body: this case applies strongly against pointed conducting rods for shipping. It will also receive a full spark at a considerable distance, if surrounded with non-conducting substances. The circumstances on which an explosion depends, are too many to be here enumerated; in general, it may be said that, with respect to a point, it will depend on

the suddenness of the discharge, on the proximity of the cloud, on the velocity in its motion, on the quantity of electricity contained in it, and on the contrary electricity opposed to it. If a small cloud hang suspended under a large cloud loaded with electric matter, pointed conductors on a building underneath, will receive the discharge by explosion, in preference to those terminated by balls; the small cloud will form an interruption, which allows only an instant of time for the discharge. If a single electric cloud be driven with considerable velocity near to a pointed conductor, the charge may be caused to explode upon it by the motion of the charged body.

A pointed conductor has not even the power of attracting the lightning a few feet out of the direction it would choose itself: of this we have a most decisive instance in what happened to the magazine at Purfleet, in Essex, Great Britain. That house was furnished with a conductor, raised above the highest part of the building; nevertheless, a flash of lightning struck an iron cramp in the corner of the wall of the building, considerably lower than the top of the conductor, and only forty-six feet in a sloping line distant from the point.

The conductor, with all its power of drawing off the electric matter, was neither able to prevent the flash, nor to turn it forty-six feet out of its way. The matter of fact is, the lightning was determined to enter the earth at the place where the board-house stands, or near it; the conductor fixed on the house which offered the easiest communication, but forty-six feet of air intervening between the point of the conductor and the place of the explosion, the resistance was less through the blunt cramp of iron and a few bricks moistened with the rain to the side of the metalline conductor, than through the forty-six feet of air to its point; for the former was the way in which the lightning actually passed.

An objection to the use of conductors of either kind may be also drawn from the accident which happened to the poor-house at Heckingham, Norfolk, (England) according to Adams (Nat. Philos.) which was struck by lightning, though furnished with eight pointed conductors, and which, Mr. A. was well assured from good authority, were uninterrupted, continuous, and at the time of the stroke perfectly connected with the common stock. Hence it is evident, that the effect of conductors, in general, is too inconsiderable either to lessen fear or animate hope.

The *thunder house*, as it is usually called, is the apparatus principally used to illustrate the Franklinian method of preserving houses from damage by lightning. It consists of a mahogany board, shaped like the gable end of a house. It is fixed upright on a horizontal board as a stand; a square hole is made in the gable board, into which is fitted, so as to go in and out easily, a square piece of wood; a wire is fixed in the one diagonal of this board, and wires are also fixed in the gable board, one from the upper part, the lower end of which comes to one corner of the square hole; the upper end of the other wire coincides with the opposite corner, and goes down to the bottom of the gable board. The upper wire has a brass ball on the top; this may be occasionally taken off, which leaves a point exposed; at the bottom of the lower wire there is a hook: connect the hook at the bottom with the outer coating of a jar, place the square piece in the hole, so that the metallic wire shall not coincide with the other two; when the jar is charged, bring the discharging rod from the knob thereof to the ball of the house; an explosion will ensue, and the square piece be driven out to a good distance from the gable board.

Put the square piece into the hole in such a manner, that the ends of the diagonal may not coincide with the ends of the wire of the gable board, then make the discharge as before, and the metallic circuit being now complete, the square board will remain in its place.

Take off the ball, and the point will prevent an explosion, and its accumulating therein in any sufficient quantity to do any damage.

The prime conductor is supposed to represent a thunder cloud discharging its contents on some metal projecting on the top of a building; and this is considered as receiving no damage when the conductor is perfect; but when the connexion is imperfect, the fluid, in passing from one part to the other, damages the building.

LIME.—Lime is an earth moderately hard, of a hot acrid taste, soluble in water, though to a small extent, producing nearly the same change on vegetable colour as the alkalies do, and strongly promoting the fusion of all earthy mixtures. See Earths.

It is always prepared artificially by heating the various species of carbonats, till the carbonic acid is driven off, and it is made in very large quantities for the important purposes of mortars and cements of different kinds, for manure, and

for other smaller uses. The process of lime-burning in the large way will be noticed in the following article.

For nice chemical purposes lime may be made by calcining in a full red heat for some hours either the white Carrara marble of the statuaries, or oyster-shells (the outer coat being first taken off). In both the lime is very considerably pure, that obtained from marble being only mixed with a small portion of silex, and sometimes with an atom of iron, and that from the shells containing only a little phosphat of lime.

To obtain lime perfectly pure, let nitric or muriatic acid (free from iron) be quite saturated with fragments of white marble, leaving some of it for a time in the solution that only the lime may be taken up; add a little perfectly caustic ammonia to the solution, which will separate any accidental impurity of iron or other earths but not the lime; then precipitate the lime in the state of carbonat by carbonated ammonia, edulcorate the precipitate, and afterwards calcine it thoroughly. If the burning be done in an earthen crucible, too strong a heat must not be used, as it would cause a portion of the lime to vitrify with, and adhere to the sides of the crucible, but with a platina crucible any heat may be given.

Oyster-shells will answer as well as marble, but the phosphat of lime, taken up by the acid along with the lime, must be first separated by pure ammonia.

The lime is known to be thoroughly calcined, when, after being moistened with water, and reduced thereby to a soft pulp, it excites no effervescence with any acid moderately dilute. The portion that has begun to vitrify with the crucible remains hard and gritty, and will not mix with water.

The most known and remarkable phenomenon attending lime is the slacking with water. When a lump of well burnt lime is dipped in water and removed after a second or two, or otherwise wetted so as not to be drenched, the surface immediately dries, after which, (a little sooner or later according to the kind of limestone employed) it becomes very hot, swells, and cracks in every direction, and falls to pieces with a snapping noise and the evolution of a copious dense steam, owing to the evaporization of the water by the intense heat generated. If a large quantity of very well burnt lime be slacked in the dark, flashes of light are also observed to come from it when breaking to pieces. The lime by this process falls into a very fine dry impalpable powder, and when cold it will not again heat by more water.

In this state it is called slacked lime, and it differs from quick or unslacked lime, as appears, simply by containing water, and probably also by having parted with a large quantity of caloric, but it does not at this time contain any notable quantity of carbonic acid. Slacked lime dried at a heat of 600° contains, according to Lavoisier, about 78 per cent. of lime and 22 of water. If slacked lime be diffused in more water it mixes uniformly with it by stirring, and forms a thick milky liquor, called by some milk of lime, but, by repose, all the lime falls to the bottom as a fine white sediment, except a small portion which the water dissolves, forming lime-water.

Lime-water, when it has been some time at rest, is always clear and transparent. It has a very strong hot disagreeable taste, and changes vegetable colours nearly as the alkalies. The actual quantity of lime contained in limewater however is very small, not being more at the utmost than about $\frac{1}{500}$ of the solution, and often much less. When lime-water is exposed to the air, a white brittle pellicle presently forms at the surface, which is the lime united with the carbonic acid, which it greedily attracts from the atmosphere, and has thereby become insoluble in the liquid. By degrees these pellicles fall down, and others succeed, till the whole of the lime has separated and the water is rendered tasteless. Carbonic acid passed through lime-water makes it instantly turbid by the separation of the calcareous carbonat, but this is again dissolved, and the liquor again made perfectly transparent by using an excess of carbonic acid.

Pure lime has not yet been crystallised artificially. On account of its very sparing solubility in water, it will not crystallise from the hot solution by cooling, like the watery solutions of barytes and strontian.

Lime by itself will not fuse in a less heat than that given by oxygen gas before the blowpipe, but it remarkably promotes the fusibility of all earthy and saline compounds, and of metallic oxyds, as already explained, under the article GLASS.

Hence it is often employed as a cheap and useful flux in the reduction of the refractory ores.

The use of lime as an essential ingredient in mortar and other cements has already been mentioned under the articles CEMENTS and LUTES and, CEMENTS (Calcareous).

Lime has a very powerful effect on vegetable and animal substances, but especially the latter, breaking down their texture, and reducing them to a soft incohesive pulp. It readily unites with oil

when any calcareous salt is added to soap, and the white curdy mass thus produced consists of the oil united with the lime into an insoluble compound.

LIME-WATER.—(See the preceding article.)

LIMESTONE.—This species may be divided into the five following families.

1. FAM. Foliated.

1. *Subsp.* Calcareous spar. Common Spar, Kirw.

Its principal colour is white, either greyish, greenish, yellowish, or rarely reddish; the other colours that it presents are leek and olive green; honey, ochre, wine, and wax yellow; flesh-red, brownish-red, and very rarely rose-red; smoke-grey passing into black; greenish and yellowish grey, and very rarely pearl-grey and light violet-blue. On the surface of the lighter coloured crystallized varieties is often observed a segment of a circle of iridescent colours. It occurs massive, in veins, disseminated, in globular and kidney-shaped pieces, in druses, and crystallized. Its primitive figure is an obtuse rhomboid, the alternate plane angles of which measure 101° 30′ and 78° 30′. Besides this it presents a vast number of varieties.

The crystals of calcareous spar are variously aggregated and often deeply imbedded; hence the rhomboidal crystals, especially the more acute ones present only trihedral pyramids, the three other faces that complete the rhomboid not appearing above the substance in which the crystals are engaged. The size of the crystals varies from $\frac{1}{10}$ of an inch or less to 12 or 14 inches in length; the dodecahedron var. 3 affords generally the largest crystals. The lateral planes of the crystals are commonly smooth and splendent.

The internal lustre varies from nearly specular to glistening, and is vitreous, inclining sometimes to pearly. Its fracture is strait and very rarely curved lamellar. It is easily divisible in three directions, and the form of its fragments is always rhomboidal. When in mass, calcareous spar occurs in large and coarse-grained distinct concretions, also in testaceous, wedge-shaped, and diverging, prismatic distinct concretions.

The transparency both of the massive and crystallized varieties is subject to much variation; in general however the crystals are transparent and semi-transparent, and the others are semi-transparent and translucent. When transparent it possesses a double refraction in a remarkable degree. In hardness it ranks between gypsum and fluor spar. It is brittle, and very easily frangible. Sp. gr. 2.69—2.72.

Certain varieties of calcareous spar, especially those from Derbyshire, become phosphorescent when laid on a hot coal.

Calcareous spar dissolves with effervescence in almost every acid, and by exposure to the blowpipe for some time it is reduced to quicklime. Most of the varieties contain a small variable proportion of iron, but the iceland spar, which is purest of all, consists only of lime, carbonic acid, and water, in the following proportions.

Lime - - -	55.5
Carbonic acid	44.
Water - - -	0.5
	100.0

Calcareous spar occurs in veins in almost every kind of rock, from the oldest granite, even to the alluvial strata. It accompanies a great variety of minerals, and is almost the constant concomitant of galena.

It is so generally distributed that a list of localities would be useless: the rarest and most beautiful crystals come from Derbyshire and Cumberland, in England; from Saxony, France, Spain, and Iceland. The double refracting Iceland spar may be considered as the purest form of calcareous spar; it appears in our cabinets in the form of rhomboidal prisms, but these are produced by the fracture of large dodecahedral crystals of var. 3.

2. FAM. Granularly foliated.

2. *Subsp.* Statuary marble. Granular marble. Primitive Limestone.

Its usual colour is snow-white, yellowish, greyish and greenish-white, rarely reddish-white: it also occurs bluish, greenish, ash and smoke grey, and greyish-black; from reddish-white it passes into pearl-grey and flesh-red, and from greenish-white into yellowish and olive-green.

Its colour is generally uniform, but sometimes it presents clouds, spots, or veins. It is always in mass. Its lustre varies from shining to glimmering, and is intermediate between pearly and vitreous. Its fracture is minutely foliated passing into splintery. Its fragments are indeterminately blunt edged. It generally occurs in granular distinct concretions; when these are very fine, the fracture approaches nearly to compact. It is translucent, and the less so, as it is the more loaded with colouring matter. In hardness it is nearly equal to the preceding; it is brittle and easily frangible. Sp. gr. 2.7 to 2.8.

In chemical characters it agrees with calcareous spar.

It occurs sometimes in mountain masses, but more frequently in beds in mountains of gneiss, and argillaceous and micaceous shistus: when in gneiss the concretions are very distinct, but when it occurs in transition rocks the concretions are hardly visible. It frequently contains other substances dispersed through its substance, such as mica, hornblende, actynolite, asbest, quartz, serpentine, galena, blende, iron pyrites, and magnetic ironstone.

The most valuable variety of statuary marble is the snow white; that of the isle of Paros in the Archipelago has supported undiminished the high reputation which it appears first to have derived from the sculptors of Greece, almost all their finest works having been formed of this material. Next in esteem is the white marble of Carrara in Italy, which is employed in most of the finer works of modern statuary. Of the coloured varieties of primitive limestone that of the island of Tiree, on the western coast of Scotland, deserves perhaps the highest place, its colour is a bright flesh-red, beautifully relieved by interspersed crystals of green hornblende; its fracture is almost splintery, and it is susceptible of a high polish.

3. *Subsp.* Dolomite.

3. FAM. Fibrous.

4. *Subsp.* Satin spar. *Common fibrous limestone*, Jameson.

Its colour is greyish, yellowish, or reddish white; it occurs in mass. Its lustre is between shining and glistening with a pearly or satiny lustre. Its perpendicular fracture is straight or waved parallel fibrous, the fibres are either fine or coarse; the cross fracture is compact splintery. Its fragments are splintery or flattened fibrous. It is translucent, and in thin pieces is semitransparent. Its hardness is a little inferior to that of calcareous spar; it is brittle, and easily frangible. Sp. gr. 2.7.

In its chemical characters it resembles calcareous spar. Its constituent parts, according to Mr. Pepys, are

Carbonic acid -	47.6
Lime - -	50.1
Water and loss -	2.3
	100.0

It occurs in strata from one to four inches thick, and is transversed by veins of pyrites.

The most beautiful is found in Derbyshire: it is susceptible of a fine polish, and is employed in inlaying, and in the manufacture of small ornaments in imitation of pearl.

5. *Subsp.* Stalactite or sinter.

The colour of stalactite is snow-white, greyish, greenish, and yellowish white; also wax and honey yellow and yellowish-brown; also yellowish, brownish, or bluish green, or mountain-green; sometimes, though rarely, flesh or peach-blossom red. The colour is either uniform or in stripes.

It occurs massive, reniform, botryoidal, tabular, stalactite, and tuberous. Externally it is rough and often drusy. Internally it has a glimmering pearly lustre. Its fracture is fibrous, more or less divergent, often completely radiated. Its fragments are indeterminately angular, or wedge-shaped. It generally occurs in curved lamellar distinct concretions, parallel with the external surface. It is more or less translucent passing into semitransparent. Its hardness is equal to that of calcareous spar. It is brittle, and easily frangible.

It forms stalactites, and various rounded projections in the caves and hollows that so frequently occur in limestone. The Grotto of Antiparos, the Woodman's Cave in the Hartz, Castleton Cavern, and other caverns in Derbyshire, Yorkshire, &c. afford abundant specimens of this mineral. Some caverns have been entirely filled by it, so that it is occasionally obtained in large masses. In this state it is called oriental alabaster, and is much employed by the statuary.

That beautiful corolloidal substance, the flos ferri, is commonly ranked among the calcareous stalactites. It has never been analysed, but from its only occurring in veins of spathose iron ore, it probably contains a large proportion of carbonated iron. Stalactites occur in abundance in many of the caverns of the United States.

4. FAM. Compact.

6. *Subsp.* Common limestone.

Its usual colour is some shade of grey, either yellowish, bluish, or smoke-grey: from ash-grey it passes into greyish-black, from yellowish-grey into yellowish-brown and ochre-yellow: it also sometimes, though rarely occurs blood-red and flesh-red, and greenish-grey. Two or more colours often exist in the same piece in the form of veins, zones, bands, stripes, clouds, and dots: the surfaces of the strata and of casual rents are often covered with black or brown arborizations. It is usually massive, but also exhibits a variety of external shapes. Internally it is dull, yet often contains shining particles that appear to be crystalline laminæ. Its usual fracture is fine splintery, but it passes into flat conchoidal, uneven, and earthy; sometimes, though rarely, it is

slaty. Its fragments are indeterminately angular, more or less sharpedged. It is translucent on the edges, moderately hard, brittle, and frangible. Sp. gr. 2.6—2.7.

It dissolves in acids with a vigorous effervescence, and when exposed to the blowpipe is converted into quicklime. It is composed of lime and carbonic acid, with a small and variable proportion of silex, alumine, the oxyds of iron and manganese, and inflammable matter.

Limestone sometimes, though rarely, occurs among the transition rocks, in which case it alternates with and rests upon slate, and has a splintery fracture, and is for the most part destitute of the remains of organized bodies.

But the principal repository for limestone is the class of secondary or floetz mountains. Among these it always occurs in strata, constituting several distinct formations: the oldest of these is that which rests upon the red sandstone, and bituminous marl slate. Some of the other formations are characterized by the shells with which they abound. Of these the least recent contain ammonites belemnites, gryphites, and turbinites, while the most modern contain various marine shells and fish. Limestone ranks among the metalliferous mountains: the ores which are deposited within it are galena and blende, more rarely fahlerz and malachite. It frequently also alternates with thin seams of hornstone or chert, as chalk does with flint.

Limestone when unburnt is used for building and paving stones, and when hard and compact enough to admit of polishing it is employed under the name of marble, in the more ornamental parts of architecture; when deprived of its carbonic acid, or in the state of quicklime, it forms the base of all the calcareous *cements*, and, is largely employed by the farmer for manure, by the tanner, the soapboiler, the calico-printer, &c. and by the smelter to facilitate the reduction of the more refractory ores.

The argillaceous limestones have for the most part a tendency to a slaty fracture, and pass into marl; their colour is principally bluishgrey or reddish, and they are readily decomposed by the action of the air; the mortar into which this variety of limestone enters possesses the quality of hardening under water, as is mentioned at large in the article CEMENT.

7. *Subsp.* Magnesian Limestone.

This substance was confounded with common limestone till Mr. Tennant undertook an examination of it; and although the external distinctive characters between the present subspecies and common compact limestone have not hitherto been laid down by any author, yet the chemical differences in the composition of the two clearly require their division into distinct subspecies. When deprived by heat of its carbonic acid it is much longer in reabsorbing it from the atmosphere than common limestone is. Mortar made of the former and employed in the outside of a building, in the space of eight years, had recovered only 47 per cent. of the carbonic acid originally contained in the stone, whereas mortar of common limestone in a year and three quarters had regained 63 per cent. of its original amount of carbonic acid. The great length of time which this magnesian limestone continues caustic is the cause of a most important difference between this and common limestone with regard to their employment in agriculture: lime of the former description is technically called hot, and when spread upon land in the same proportion as is generally practised with the latter, greatly impairs the fertility of the soil, and when used in a somewhat larger quantity entirely prevents all vegetation. The habitudes of the two subspecies, with regard to their solution in acids, are also different, in the same manner as dolomite differs from granular marble, the magnesian limestone being much more slowly soluble than the other.

It occurs in strata at Bredon-hill, near Derby; at Matlock in the same county. In the counties of Yorkshire and Nottinghamshire it extends from near Worksop to the vicinity of Ferrybridge, a distance of above thirty miles. It is also common in Northumberland. The Minster and city walls of York, and Westminster-hall in London, are built of it. It sometimes though rarely contains shells, and appears to rest upon secondary limestone.

According to Mr. Tennant's analysis it contains from

20.3	to	22.5	Magnesia.
29.5	—	31.7	Lime.
47.2	—	——	Carbonic acid.
0.8	—	1.24	Clay and oxyd of iron.

5. *Fam.* Granular.

8. *Subsp.* Roestone.

We have also examined the magnesian lime stone found in this country. See AGRICULTURAL TRANSACTIONS. Professor Cooper also examined it, but with more accuracy. See EMPORIUM, new series.

Its colour is hair and chesnut brown, or yellowish-brown, or ash-grey. It occurs in mass, and is without lustre. It is composed of small and fine-grained

globular distinct concretions; hence its fracture in the great is granular, but that of each distinct concretion is fine splintery. Its fragments are indeterminately angular, blunt-edged. It is opake passing into translucent on the edges It is considerably softer than common limestone. It is brittle, and very easily frangible. Sp. gr. 2.45—2.55.

It occurs in beds interposed between sandstone, common limestone, and gypsum.

The Ketton-stone of England belongs to this subspecies, as also does the Portland stone. It is found also in Sweden, Swisserland, and especially in the province of Thuringia, in Saxony.

It is used for building, and as a manure, especially when broken down by exposure to the air: but is not burnt into quicklime on account of the clay with which it is intimately mixed.

It has obtained its present name from the resemblance which many of its varieties bear to the roe of fish; indeed it was formerly ignorantly supposed to be this very substance petrified.

9. *Subsp.* Peastone.

Its usual colour is yellowish-white, whence it passes on one hand to snow-white, and on the other to light yellowish-brown. It occurs in mass, but when it forms the lining of cavities it is then reniform or botryoidal. Internally it is dull: its fracture is difficult to determine, but appears to be even: its fragments are indeterminately blunt-edged. It is composed of spheroidal distinct concretions either coarse or small, and these are again composed of thin concentric curved lamellæ. It is opake, soft, and easily frangible.

It occurs in considerable masses near the hot springs of Carlsbad, in Bohemia, and appears to be a deposit from these fountains. The centre of each concretion is usually a grain of sand, but sometimes a small cavity filled with air. It is also said to occur in Hungary, and at Perscheesberg in Silesia.

On Marble.—In the language of the statuary and architect all stones come under the name of marble that are harder than gypsum, occur in considerable masses, and are capable of a good polish.

Hence, not only many varieties of limestone, but also granite, porphyry, serpentine, and even the fine-grained basalts, are called marble. Among mineralogists however the term is used in a more restricted sense, being confined to those varieties of dolomite, swinestone, and compact and granularly foliated limestone that are capable of receiving a considerable polish. Of these calcareous marbles the most valuable for hardness, durability, and colour, are procured from Italy, from the Greek islands, and from Syria: the ancient Romans, when at their height of civilized luxury, also obtained from Numidia and other districts in Africa some highly-esteemed varieties of marble.

The white granularly foliated limestone has always been the favourite material of the sculptors of ancient Greece and modern Europe, both on account of its pure colour, its delicate translucence, and its granular texture, which renders it much more easy to work than compact limestone. Dolomite possesses similar advantages, and is somewhat softer and of a finer grain: several of the smaller works of the Greek sculptors are of this material. The two great sources whence the statuary marble of Europe has been procured are Paros and Carrara. The Parian marble is the purest, consisting of hardly any thing else than carbonat of lime; hence it is softer, somewhat more transparent, and of a more visibly laminated texture than that of Carrara, which is mingled, often in considerable proportion, with granular quartz.

The most esteemed of the architectural marbles are the following.

1. A deep blue-coloured marble, called bardiglio, from Carrara, which appears to differ only in colour from the white statuary marble of the same place.

2. Cipolin marble, which is statuary marble traversed by veins of mica.

3. Lumachelle marble, which is a secondary compact limestone of a grey or greyish-brown colour, holding shells that still retain their pearly lustre. The fire marble of Bleyberg, in Carinthia, is the most valuable of this variety; the base is a greyish-brown compact limestone, in which are implanted shells of a fire colour and beautiful iridescent lustre.

4. Florentine marble, which is a compact very argillaceous limestone, of a grey colour, with designs of a yellowish-brown representing architectural ruins.

5. The yellow marbles of Syria, Sienna, and Arragon.

6. The green marbles known by the names of campan, verde antiche, verde di Corsica, &c. which are mixtures of granularly foliated limestone, calcarous spar, and serpentine, with threads of asbestos.

7. A very rich breccia, called brocatelli, containing small fragments of yellow-red and purple limestone, cemented by semi-transparent white calcareous spar.

Of the marbles that the British islands produce, that of Tiree deserves the first place; and if its colours were not apt to

fade, it might rank among the most beautiful even of Italy. The counties of Devonshire and Derbyshire also afford several varieties of considerable beauty, though by no means to be compared with the most esteemed of Italy and Spain. There are a variety of limestones, marbles, &c. found in the United States, especially on the Schuylkill, not far from Philadelphia, equal almost to any of the foreign.

On Limestone.—Although all the species with their varieties that are described in this article may, properly speaking, be called limestone, since they consist almost entirely of calcareous carbonat, and may by burning be brought to the state of quicklime, yet we shall find in fact, that the substances belonging to the family of compact limestone are the only ones that are or that can be advantageously employed for this purpose in the large way Sometimes calcareous spar, and, more frequently, statuary marble, are used in the laboratory for the purpose of procuring a lime purer than ordinary for the purposes of chemistry. But owing to the crystalline texture of these substances, the laminæ, of which they are composed, part from each other during the volatilization of their carbonic acid, so that by the time they are rendered thoroughly caustic their cohesion is destroyed, and they are reduced nearly to the consistence of sand; a circumstance which must always prevent them from being used in kilns of the common construction. The limekiln at present almost universally employed is a cup-shaped concavity in a solid mass of masonry, open at the top, and terminated at the bottom by a grate, immediately above which is an iron door that may be opened and closed at pleasure. This simple furnace is first charged with fuel (either wood or coal, but more commonly the latter in Europe), upon which is afterwards laid a stratum about a foot thick of limestone, broken into pieces not larger than the fist: to this succeeds a charge of fuel, and so on alternately, keeping the kiln always full. The pieces of limestone descend towards the bottom of the kiln, in proportion as the fuel is consumed, being in the mean time kept at a pretty full red heat. At this temperature the water and carbonic acid are driven off, and by the time that the limestone arrives at the bottom of the kiln, which happens in about 48 hours, it is rendered perfectly caustic. The door above the grate is then opened, and all the lime below the next descending stratum of fuel is raked out: the remaining contents of the furnace sink down, and a fresh charge is laid on at top. The compact limestone, after having undergone this process, though much lighter and porous than before, still retains its figure unaltered, hence it is readily separable from the ashes of the fuel, and is sufficiently hard to be carried from place to place without falling to pieces. For some further remarks on the different varieties, see CEMENTS, CALCAREOUS.

LIME, on the use of—mixed with gunpowder, in rending rocks and stones. By H. D. Griffith, esquire, of Cærhun, near Conway, North Wales. From the letters and papers of the Bath and West of England Society.

"Having been for some time in the habit of perusing your interesting papers on agriculture and other subjects, I am induced to lay before the society a circumstance, which, though perhaps familiarly known to them, might, if more generally divulged through the channel of their publications, be of infinite advantage to the public.

"In clearing my lands of the heaps of stones with which this country every where abounds, I found the quantity of gunpowder used in the operation, to amount to a considerable sum at the end of the year; and, as the price of this article has been increasing of late to an enormous amount, I had recourse to an expedient, by which the expense of it has been materially diminished.

"I weighed out two pounds of gunpowder, and one pound of quick lime, well dried and pulverized; which, after having been thoroughly mixed with each other, I delivered to the blaster, with directions to apply it, in similar quantities as he would have done the gunpowder by itself. I then selected six of the hardest granites I could find for the experiment; and the effects of the explosion were precisely the same as if gunpowder alone had been used. It now occurred to me, that this might be fallacious, and that a smaller proportion of gunpowder would produce the same effect as a larger; I accordingly ordered the man to bore holes in a similar number of stones, of the same texture and size with the former, and to put in a less quantity of gunpowder, by one-third, than he would have done if it had been left to his own management. The stones were separated by the shock; but the difference in the effect was manifest to every person in the field; those with the mixture of lime and gunpowder having been much more effectually broken and shattered than the others.

"After the success of this experiment, I have constantly adhered to the practice; and am so satisfied of its utility, that I

wish to see it more generally adopted. One thing is certain, that a mixture composed of equal parts of quick-lime and gunpowder will explode; and, if this mixture were used merely as a train of communication to the powder within the stone, what a national saving would it be in works carried on upon an extensive scale."

LIME, in agriculture. See AGRICULTURE.

LIME KILN. See LIMESTONE.

LINEN. See MANUFACTURE OF CLOTH.

LINSEED-OIL. See OILS, FIXED.

LIQUATION, or ELIQUATION. This process will be described under the article SILVER.

LIQUOR, spirituous. The fermented fluids, which have an intoxicating effect, such as rum, gin, &c. are called spirituous liquors. Of the different kinds we might enumerate many; but as the several liquors will be noticed under their different heads, we refer the reader to the articles RUM, BRANDY, GIN, SPIRITS, ALCOHOL, WINE, &c. For the mode of clarifying liquors, see CLARIFICATION and FILTRATION; and for the distillation of liquors, see DISTILLING.

LITHARGE. Litharge may be easily revived into lead; accordingly, much of that which is produced by refining in the large way is reduced, by being melted upon burning coals. The part of it which is least altered by mixture with other metals is thus reduced, and by this method good and saleable lead is obtained. The rest of the litharge of these refineries is sold and used for various purposes. Potters use much of it for glazing their ware. It is employed for the preparation of some plasters, and other external remedies; and also in painting, to render linseed oil drying. Lastly, it is added in the composition of some glasses, for it is very fusible, and assists the fusion of other substances. It has in general the same properties as the other oxides of lead. All the litharge which is commonly sold comes from refineries. The quantity formed there is more than sufficient for the demand. See LEAD.

LITMUS, or ARCHIL. (*Tournesol*, Fr.) —This beautiful but perishable dye is a violet red paste, prepared from a species of lichen, which grows abundantly in the Canary Islands, in the south of France, and in some other parts. Many other species of lichen have also the property of assuming a beautiful purple, when prepared in the same manner as litmus.

Archil, by which name it is better known in commerce, is generally in the form of cakes like anotto, which are prepared largely in Holland, and in London, for the use of the dyers.

The Dutch process has long been concealed as much as possible, but it is known to be effected by fermenting the moss or lichen, and adding alkalies and urine. The following is given as the exact process. The lichen is first dried, cleansed, and reduced to powder in a mill like the oil-mill. The powder is then thrown into a trough with one half its weight of pearl-ash, and moistened with a little human urine, and allowed to ferment. This fermentation is kept up for some time by successive additions of urine till the colour of the materials changes first to red and then to blue.

When in this state it is mixed with a third of its weight of very good potash, and spread upon deep wooden trays till dry. A quantity of chalk is added at last, apparently with no other object than to increase the weight.

There are several other kinds of moss or lichen, which will assume by a similar preparation the rich colour of the true archil, which is a crimson tending to violet; and have occasionally been employed for the same purposes in dyeing.

The colour of archil is readily extracted by water or by alcohol. The colour of the watery solution, or of any substance dyed with it, soon fades by exposure to air, and hence it is used to give a gloss or finish to the deeper and more permanent colours. It is much employed for this purpose in the dyeing of silk, stuffs, and ribbons.

All acids and salts with excess of acid, such as alum or tartar, change the natural violet-purple of litmus to red; and this change is effected so readily and perfectly with a very small degree of acidity, as to render this colour a valuable test to the chemist, to detect the presence of uncombined acids. Even the carbonic acid in so small a proportion as that in which it exists in the breath (or about 5 or 6 per cent. of the bulk of the air expired) may be made to change the colour of litmus infusion, if a little of it diluted, so that the purple-blue is scarcely visible, be shaken in a phial containing air expired from the lungs. It is probable too, on account of the carbonic acid from the atmosphere, that paper or any thing else tinged with litmus reddens before the colour is altogether lost.

LIXIVIUM. This term signifies nearly the same as LEY.

LOAM. A natural mixture of clay and sand. The coloured clays and loams parti-

cipate of iron ; hence many of these melt in a strong fire, without any addition; both clay itself, and mixtures of it with crystalline earths, being brought into fusion by ferruginous oxides, though the fusible mixtures of clay and calcareous earths are by the same ingredient prevented from melting. The bricks made from some loams, particularly the Windsor, are, when moderately burnt, remarkably free, so as to be easily rubbed smooth, cut, sawed, grooved, &c. Hence their use in building furnaces, &c. They bear a considerably strong fire, but have been frequently melted in a vehement one.

LOADSTONE. See Iron (*Ores of*.)

LOGWOOD, or Campeachy Wood. The tree that furnishes this wood (the *Hæmatoxylum Campechianum*) grows to a very large size in various parts of the West Indies, and especially on the bay of Campeachy and along the American continent, and is imported largely into this country from Jamaica for the use of the dyer. It usually comes over in moderate sized logs, of a very dark violet-brown colour, very hard and heavy. Before it is used it is broken down or rasped in powerful mills into fine chips.

The taste of logwood is mildly and agreeably astringent, and when long chewed it leaves a pleasant sweetness in the mouth. Both water and alcohol take up a considerable part of the soluble portion of the wood (alcohol much more than water), and thereby become tinged of a deep purple-red or brown.

Acids added to the watery decoction turn it yellow, but alkalies give a very deep purple colour, but without forming any precipitate.

Alum added to the decoction of logwood causes a violet precipitate or lake, and the supernatant liquor also remains violet, and gives a fresh portion of lake on the affusion of an alkali.

The salts of iron give an inky black with all the solutions of logwood, under the same circumstances as with galls, as explained under the article Iron, whence the presence of gallic acid in logwood is proved.

The solutions of tin form a very fine violet or plumb colour lake with the decoction of logwood, and totally precipitate the colouring matter, so that the supernatant liquor is quite clear and colourless.

Logwood is used in dyeing, either to give its own natural purple (with several shades or variations according to the mordant used) or to heighten and improve the common black with iron and galls. It is found in this latter method to give a peculiar gloss and lustre which renders it a very valuable dyeing material. See Dyeing.

LOGS OF WOOD, apparatus for splitting. A simple apparatus for breaking up logs of wood, by the explosion of gunpowder. By Mr. Richard Knight. Trans. Soc. Arts, 1802.

"This apparatus consists of a gouge and augur for boring a hole into the wood to receive the powder. An iron or steel rending or blasting screw, which is made use of instead of a plug or stemming to confine the powder. The handle of this screw should be divided into two forks or prongs in such manner as to admit a lever for the purpose of winding it into the wood. The dimensions of the screw should be such that it may not too easily be wrought into the hole, previously made by the augur. Through the centre of the screw is a small hole, to which a priming wire is fitted for the purpose of occasionally clearing the hole, and introducing a quick match. This hole should be as small as is convenient to prevent the escape of the ignited powder. The match may be made of cotton or twine thread, steeped in a solution of saltpetre. A straw, however, filled with powder, in the manner in which the miners use it answers very well. A leather thong may be attached to the lever, in order to fasten it, occasionally, to the screw, to prevent the loss of the latter, in case it should be thrown out when the log is burst open; a circumstance which, the inventor says, does not often occur, as when the wood was sound he has always found the screw left fixed in one side of the divided mass. Should this not be thought a sufficient security for the screw, it may be fastened by a chain or rope to any heavy or fixed object."

LOOKING GLASS. See Mirror, the articles Foliating, Silvering, and Glass Making.

LORICATION. The same with Coating, which see.

LUDUS HELMONTII. An indurated marle, composed of various pieces of a whitish brown colour, separated into a great number of polygonous compartments, the boundaries of which are formed of matter of a lighter colour than the rest. According to Bomare, the Ludus stellatus Helmontii, found in the county of Kent, England, is covered with a kind of striated selenite, resembling the zeolite. It is for the most part of a globose figure, seldom flat, but often convex on the outside. And sometimes with a concave surface.

LUMACHELLA. A conglutinated, calcareous stone, composed of shells and

coral, united together by a cement of the same nature. When they have many colours, they are called marbles, and employed as such. In the island of Gottland, there is found one of this kind of one colour only, which on that account is not called marble.

LUTE. In many chemical operations, the vessels must be covered with something to preserve them from the violence of the fire, from being broken or melted, and also to close exactly their joinings to each other, to retain the substances which they contain, when they are volatile and reduced to vapour. For this purpose several matters are employed, called in general lutes.

The lutes with which glass and earthen ware retorts are covered, ought to be composed of nearly equal parts of coarse sand and refractory clay. These matters are to be well mixed with water, and a little hair, or cut tow, so as to form a liquid paste, with which the vessels are to be covered, layer upon layer, till it is of the required thickness.

The sand mixed with the clay is necessary in this lute, to prevent the cracks which are occasioned by the contracting of clay during its drying, which it always does when it is pure. The hair serves also to bind the parts of the lute, and to keep it applied to the vessel: for, notwithstanding the sand which is introduced into it, some cracks are always formed, which would occasion pieces of it to fall off. This lute is applicable to the junctures of vessels requiring much heat, but it must be quite dry before they are used.

Mr. Willis has recommended as a coating for earthen retorts, a solution of borax in 8 parts of boiling water, brought to the thickness of cream with slaked lime; which, when dry, is to be covered with a thin paste of slaked lime and linseed oil.

The lutes with which the joinings of vessels are closed, are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels.

When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or of linen, covered with flower-paste. In such cases also slips of wet bladder are very conveniently used.

Almond powder, mixed with water or mucilage to the consistence of a stiff paste, makes a good lute.

When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quick-lime slaked in the air, and beaten into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which are to be applied exactly to the joining of the vessels. This lute is very convenient, easily dries, becomes solid, and sufficiently firm. The whites of eggs with their yolks, and about half their weight of powdered chalk, or lime, thoroughly slaked in the air, applied in this manner, is sufficient, according to Prof. Paysse for the oxigenized muriatic acid. Of this lute vessels may be formed hard enough to bear polishing on the wheel.

Gluten and lime make a strong lute.

Lastly, when saline, acid, and corrosive vapours are to be contained, we must then have recourse to the lute called fat lute. This lute is made by forming into a paste some dried clay finely powdered, sifted through a silken scarce, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, that is, oil which has been rendered drying by litharge dissolved in it, and fit for the use of painters. This lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied, by flattening them, to the jo nings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen spread with lute of lime and whites of eggs. These slips are to be fastened with packthread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone.

Fine porcelain clay, mixed with a solution of borax, is well adapted to iron vessels, the part received into an aperture being smeared with it.

A Lute to mend all Sorts of broken Vessels.—Take any quantity of white of eggs, and beat them well to a froth. Add to this soft curd cheese, and quicklime, and begin beating a-new all together. This may be used in mending whatever you will, even glasses, and will stand both fire and water.

Another, for the same Purpose, which resists Water.—Take quick-lime, turpentine, and soft curd cheese. Mix these well together; and, with the point of a knife, put of this on the edges of the broken pieces of your ware, then join them together.

A cold Cement for Cisterns and Fountains.—Take litharge and bole in powder, of each two pounds; yellow ochre and resin, of each four ounces; mutton suet, five ounces; mastich and turpentine, of each two ounces; oil of nuts, a sufficient

quantity to render it malleable.—Work these all together; and, then it is fit for use.

To lute or plaster Earthen Pots or Pans with Linen-cloth, to stand the Fire.—Soak your linen-cloth in salt water, and let it dry by degrees in a shady place; then dip it in yolks of eggs well beaten. Having first rubbed the place you intend to lute thinly over with the above, clap on your cloth, smooth and even; and, when dry, you may use your pan or pipkin, and set it on the fire for boiling any thing you have occasion for; it will be as sound as it was before it was broke or cracked. See CEMENT.

LYCOPODIUM. The fine dust of lycopodium, or clubmoss, is called by some, on account of its great inflammability, vegetable sulphur. The dust is properly the seeds of the plant. There are sundry other vegetables, as polypodies, ferns, coniferous trees, &c. the seeds of which are like a yellow, impalpable farina, so subtle as to be blown away by the least motion of air: it is this dust which has given rise to some reports of showers of brimstone.

The dust of lycopodium, diffused or strewed in the air, takes fire from a candle, and burns off like a flash of lightning. It is used in the London theatres. A quantity laid together upon burning coals does not flame, but smokes away with a fœtid smell: burned in a red hot crucible, it leaves a very small proportion of a light cobweb-like matter. It does not, as some report, take fire from flint and steel, nor explode like gunpowder; nor does it seem to detonate more violently with nitre than other inflammable matters do. Olearius relates, that the Russians employ much of it in fire-works, but does not inform us in what manner.

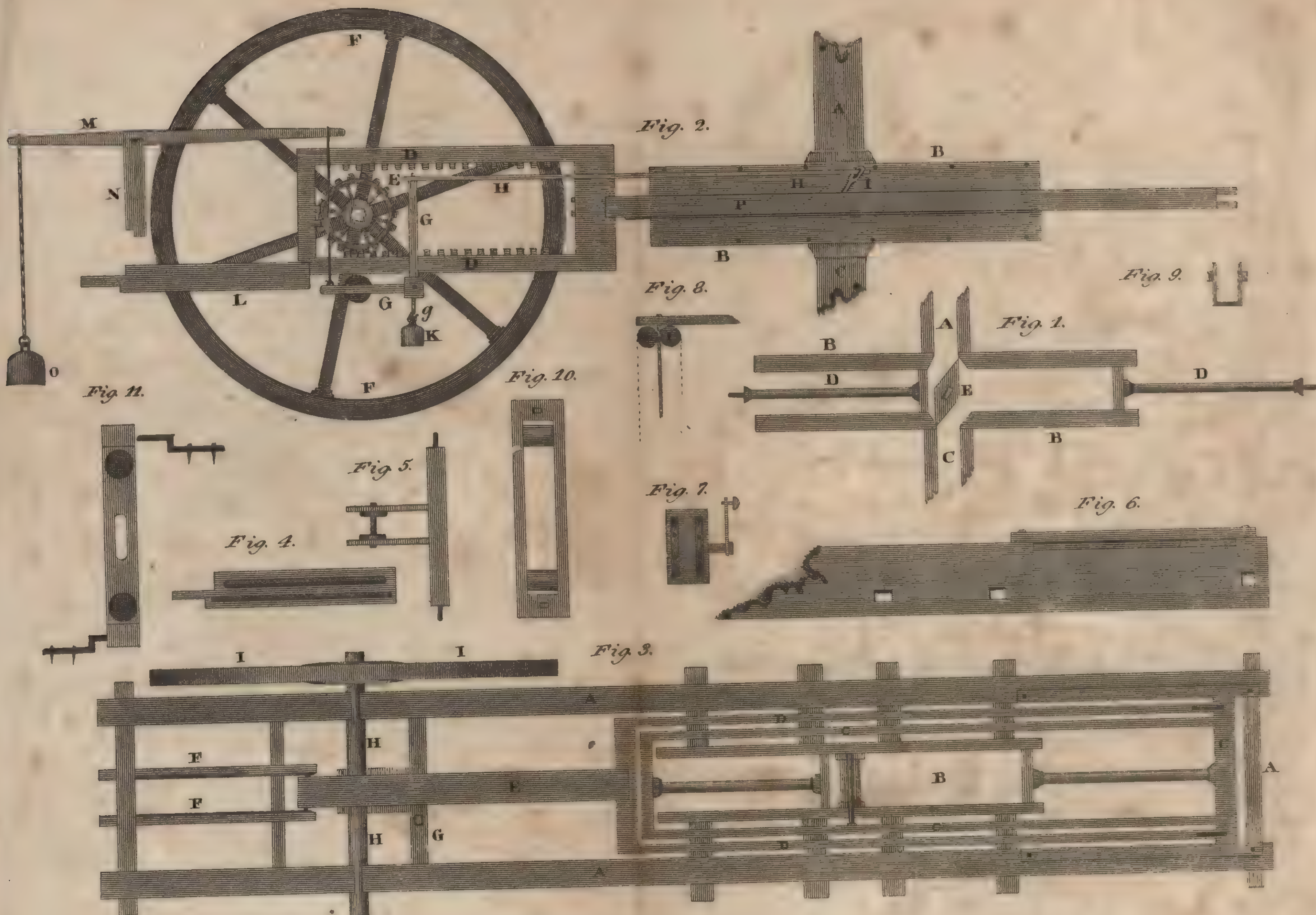
There is a curious experiment of taking a shilling from the bottom of a vessel of water without wetting the hand. It is said to be done by strewing a small quantity of the dust of lycopodium on the surface of the water, which it so strongly repels, as to form a covering for the hand, and defend it from the contact of the water. If a handkerchief be strewed over with this dust, water may be tied up in it.

Some of the species of lycopodium are good dyes. Wool or silk boiled in a decoction of the l. complanatum, or l. clavatum, and then immersed in a weak infusion of brasil, acquires a good and very fast blue. All acids, however, redden it; but the colour is again restored by alkalis. By increasing the quantity of brasil the colour may be brought to a puce. The l. annotinum treated in the same way produces grays; as do the l. selago, and selaginoides, more or less inclining to blue or violet.

All the species appear to be good mordants. The bark of the young shoots of plumtrees, affords, by their means, a fine carmelite, and that of the populus dilatata, a permanent yellow. See also LICHEN.

END OF THE FIRST VOLUME.

HYDROSTATIC ENGINE.



Engraved by H. Anderson, from an original drawing by W. Lehman.

HYDROSTATIC ENGINE.

This invention, for which Messrs. Long and Hauto, have recently taken out letters patent, under the authority of the United States, and which they have secured in England, Scotland and Ireland; is offered to the public, as a valuable and cheap substitute for the common overshot wheel, in all situations, where there is a scarcity of water, with a fall of 25 feet and upwards.

This engine bids fair, with the improvements that ingenuity may suggest, to become one of the most powerful, and at the same time, one of the most simple water machines, that ever was invented.

References to the Plate.

Fig. 1. A perpendicular section of the box, &c. A a tube or canal, through which the water is conveyed into the engine. BB a box or cylinder, on which the pistons move. C a tube, that conducts the water from the box. DD the pistons, with their rods. E a valve, turning back and forth on a gudgeon, passing through its centre, and thus opening a communication alternately between the tube A, and each end of the box, and at the same time opening a communication between the box and the tube C, so that the water may be discharged from either end of the box, whilst the other is filling.

Fig. 2. A perpendicular section of the engine. ABBC, the same as in Fig. 1. DD a rack, the sides of which act alternately on the rack-wheel, thus producing a continued rotatory movement. Its change from side to side, is effected by means of cogs in the ends, which gearing into the cogs of the rack-wheel, alternately raise and lower it. E the rack-wheel. FF a fly-wheel turning on the shaft of the rack-wheel. GG a dog, moving on its axis *g*, at every change of the rack, and thus giving a reciprocated motion to the valve-rod. HH the valve-rod. I the winch acted upon, by the valve-rod, and giving motion to the valve, by means of its gudgeon. K a weight, suspended from the valve-rod, by a line passing over pullies, in the top of the dog. L one side of the groove-box to regulate the movements of the rack. M a lever connected with the dog by rods of iron. N one of the standards that support the lever. O a weight to balance the rack. P one side of the sweep.

Fig. 3. A horizontal section of the engine. AAA the frame of the engine. B the box with its pistons, &c. CCC a carriage connecting the pistons, and moving outside of the box. DD the sweeps connected to the carriage, by means of clevices, so that it may vibrate, in conformity to the movements of the rack, which is attached to it. E the rack as represented at D, Fig. 2. FF the sides of the groove-box. G the dog. HH the main shaft, upon which the fly and rack-wheels turn, and to which other machinery of any kind may be attached. II the fly-wheel.

Fig. 4. An internal view of one side of the groove-box, in which the sliders are so disposed, as to keep the sides of the rack alternately in gear with the rack-wheel. The sliders represented by shades in this figure, are to consist of iron, and to be made fast to the sides of the groove-box, by means of screw-bolts. The uppermost is so constructed, as to permit the regulator in the end of the rack to pass around it.

Fig. 5. A view of a part of the dog, and its friction wheel, upon which the weight of the rack is supported.

Fig. 6. A view of one side of the frame at the back part of the machine, showing one of the grooves, in which that part of the carriage moves, to which the sweep is attached.

Fig. 7. A side view of the valve, with the winch by which it is turned.

Fig. 8. The pullies in the top of the dog, together with a part of the valve-rod.

Fig. 9. The carrier or regulator, to be attached to the lower part of the rack, at its outermost end. The ears upon the sides are fitted to the grooves of the groove-box, so that they pass entirely round the uppermost slider.

Figs. 10 and 11. The parts of the machine represented by these figures, are intended for a substitute for the groove-box and sliders. A model has been constructed on this plan, and it is found to answer the purpose far better, than the original plan. The greater part of the friction of the rack is completely done away by it. These figures represent different views of a catch-frame, with friction-wheels, bolts, and bolt-mortices. The

friction-wheels are placed so far asunder, as to admit the rack to pass freely between them. The frame at every change of the rack, rises and falls with it. It is confined in such a manner by the bolts, that it keeps the sides of the rack alternately in gear, with the rack-wheel. The bolts slip alternately into the mortices, by means of small weights, acting upon angular leavers or dogs; and are drawn out of them again, by the ends of the rack striking against pins or knobs, in the bolts.

According to Fig. 1. as the water acts alternately upon the pistons, it follows, that a reciprocated rectilinear motion is produced. This motion is accompanied by a power equal to the weight of a column of water, whose base is the area of one of the pistons, and whose height is equal to the whole perpendicular fall of the water. For instance let the whole perpendicular fall be 33 feet; the weight or power will be 15 pounds upon every square inch of the piston. When the fall is 66 feet, the power is 30 pounds upon the square inch, and a fall of 132 feet will give a power of 60 pounds, upon every square inch of the piston, and so on. In order to apply the power thus acquired to machinery, it is necessary that a rotatory movement should be produced. The manner in which this is effected is shewn by Fig. 2.; by which it appears that the rectilinear movement bears the same relation to the rotatory, that a line of tangent does to its circle; and this indeed is the only direction, in which a power acting in a right line, can produce a rotatory movement, without a very considerable loss.

It may be objected that the unavoidable friction to which the engine is liable, is sufficient to counterbalance all the advantages it might otherwise have, over the wheel, but an undeniable fact, which we will here introduce, will place this point beyond all controversy. An engine has been erected, at Mr. Bayly's brewery in Germantown, for the purpose of grinding malt. It is constructed on the original plan, viz. with sliders to regulate the movements of the rack. It is situated on a small stream of water, rising out of the ground, a few rods above the dam. The fall from the surface of the water in the dam, to the bottom of the machine, is equal to 25 feet perpendicular height. With this fall, grinding at the rate of 20 bushels per hour, the engine expends 100 gallons of water per minute. A grist-mill having an equal fall of water, and grinding at the rate of 3½ bushels of wheat per hour, requires about 400 gallons of water per minute, to turn it.

Farther information on the subject and licenses may be obtained, by applying to the patentees in Germantown, near Philadelphia.

APPENDIX.

BLEACHING.

Observations on the machinery used in modern bleachfields, with a description of the different apparatus referred to in the article on Bleaching, accompanied with plates.

The machinery and utensils used in bleaching are various, according to the business done by the bleacher. Where linen or heavy cotton cloths are whitened, and the business is carried on to considerable extent, the machinery is both complicated and expensive. It consists chiefly of a water-wheel sufficiently powerful for giving motion to the wash stocks, dash wheels, squeezers, &c. with any other operations where power is required.

Figures 6. and 7. Plate I. *Bleaching*, represent a pair of wash stocks. AA are called the stocks or feet. They are suspended on iron pivots at B, and receive their motion from wipers on the revolving shaft C. The cloth is laid in at D, and, by the alternate strokes of the feet, and the curved form of the turnhead E, the cloth is washed and gradually turned. At the same time, an abundant stream of water rushes on the cloth through holes in the upper part of the turnhead. Wash stocks are much used in Scotland and in Ireland. In the latter country, they are often made with double feet, suspended above and below two turnheads, and wrought with cranks instead of wipers. Wash stocks, properly constructed, make from 24 to 30 strokes per minute.

This mode of washing is now entirely given up in Lancashire, where a preference is given to what are called dash wheels and squeezers. The dash wheels are small water wheels, the inside of which are divided into four compartments, and closed up, only leaving a hole in each compartment for putting in the cloth. There are, besides, smaller openings for the free admission and egress of the water employed in cleansing. The cloth, by the motion of the wheel, is raised up in one part of the revolution of the wheel; while by its own weight it falls in another. This kind of motion is very effectual in washing the cloth, while, at the same time, it does not injure its strength. This plan, however, where the economy of water is an object of any importance, is very objectionable, because the wheel must move at by far too great a velocity to act to advantage as a water wheel.

Fig. 1. Plate I. represents a dash wheel constructed to receive its motion from a shaft A, connected either with a water wheel or steam engine. The dash wheel, CD, is fixed on a separate axis, and is engaged or disengaged from the rest of the mill work by a very simple contrivance On the end of the shaft AB is a face wheel FG, with projecting teeth made to correspond with those of a similar face wheel HI. The axis of the dash wheel is made moveable endways; by sliding it forward, the teeth lay hold of one another, and the dash wheel is thus carried round by the mill; by the sliding it backward, the teeth are disengaged, and the dash wheel ceases to move. LM represents the lever for this purpose. NNNN Fig. 3. are the holes for introducing the cloth into the four compartments; the partitions are equidistant from the holes. O Fig. 2. is the pipe which supplies the water for cleansing the goods. PQ is an open circle in the back of the weel for introducing the water from the pipe O. The circle has a number of wires set all around to prevent any part of the cloth from escaping through the circle PQ. Near the circumference of the wheel are other holes, through which the water finds its way after passing from the cloth. Dash wheels are made to engage and disengage by various other modes than that which is described above. Circumstances make it necessary to vary these; and a judicious mill-wright will be at no loss how to adapt the mode of throwing the wheel in and out of gear to the rest of the mill-work.

A dash wheel, six feet and a half in diameter, and two feet and a half wide,

making twenty-two revolutions per minute, is the most approved size and dimensions. The Plate represents the kind used in Lancashire, and in some parts of Scotland. In the neighbourhood of London, they are a little different in the mode of introducing the water. Instead of having the circumference close boarded, as in Lancashire, they are made of sparred work: The end of the water pipe is flattened so as to make the aperture very wide and narrow; and it is applied near the upper part of the circumference.

After the process of washing by the dash wheel, the water is compressed from the cloth by means of squeezers.

Squeezers consist of a pair of wooden rollers, which, in moving, draw the cloth through between them. The lower roller receives its motion from a mill, and the uppermost is pressed down upon it by means of levers. Till of late, these rollers were fixed in strong wooden frames; but the framing is now generally made of cast iron, which makes a neater and more durable piece of work.

Figures 4. and 5. Plate I. represent one of these machines having a cast iron framing, as constructed by Mr. Parkinson of Manchester. A is the lower roller. B the upper roller. CD a lever which presses upon the brass of the upper roller. FE another lever to increase the power connected with CD. The extremity of F is kept down by a pin. In some cases a weight is used in place of the pin

The improved mode of bucking was the invention of Mr. John Lowrie, a native of Glasgow. It is now practised by many bleachers in Lancashire, some on more perfect plans than others; but we shall give the description of the kind of apparatus best approved of by those whose experience and skill have rendered them the most competent judges.

In Fig. 2. Plate II. *Bleaching*, ABCD is the wooden kieve containing the cloth. CEFE represents the cast-iron boiler. GG the pump. IK the pipe of communication between the kieve and the boiler. This pipe has a valve on each of its extremities; that on the upper extremity, when shut, prevents the ley from running into the boiler, and is regulated by the attendant by means of the rod and handle IB. The valve at K admits the ley; but, opening inwards, prevents the steam from escaping through the pipe IK. The boiler has a steam tight iron cover IL; and at CD, in the kieve, is a wooden grating, a small distance above the cover of the boiler.

At MNO is a cone and broad plate of metal, in order to spread the ley over the cloth. It is hardly necessary to say, that the boiler has a furnace, as usual for similar purposes.

While the ley is at a low temperature, the pump is worked by the mill or steam engine. When it is sufficiently heated, the elasticity of the steam forces it up through the valves of the pump, when it is disjoined from the mill.

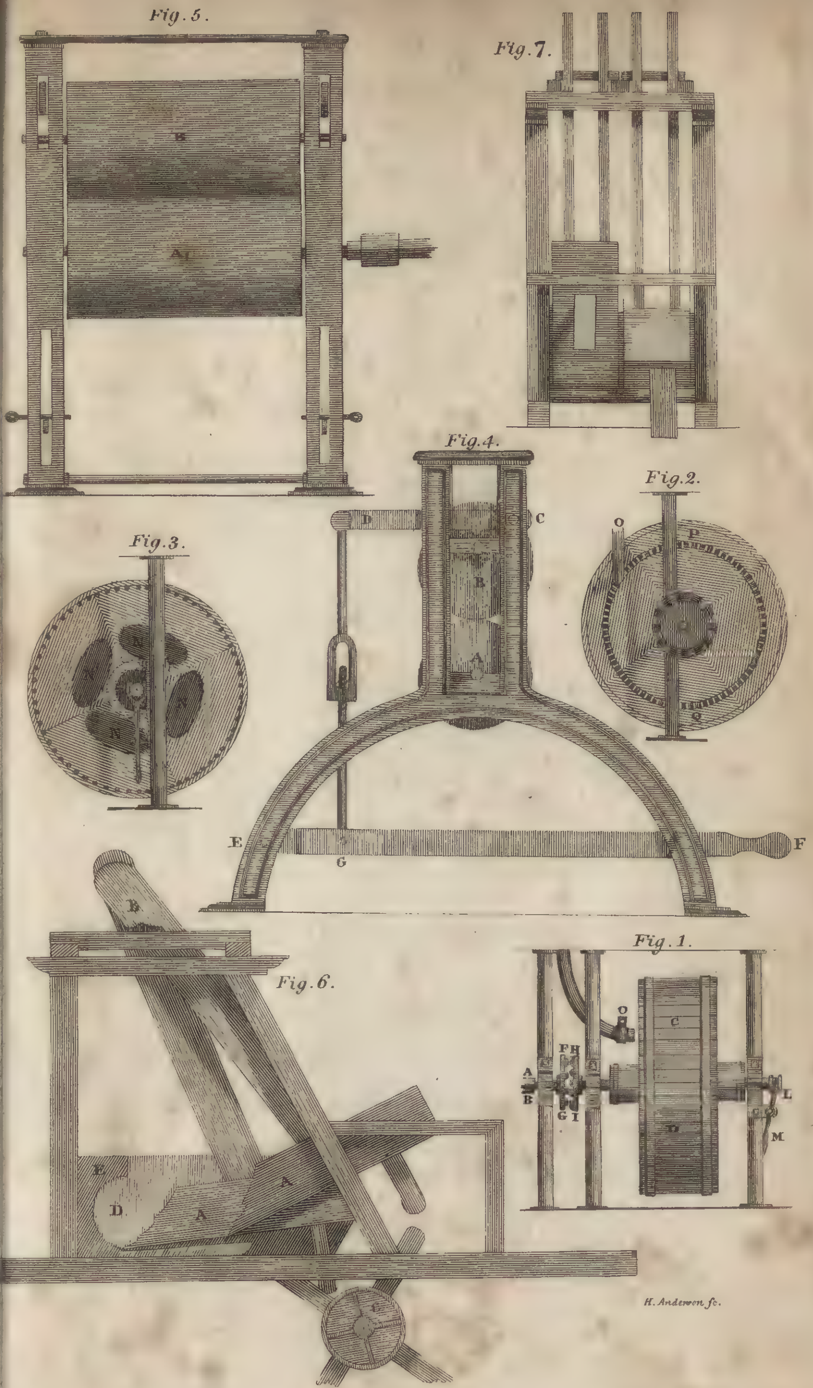
NP is a copper spout, which is removed at the time of taking the cloth out of the kieve.

The boilers used in bleaching are of the common form, having a stopcock at bottom for running off the waste ley. They are commonly made of cast-iron, and are capable of containing from 300 to 600 gallons of water, according to the extent of the business done. In order that the capacity of the boilers may be enlarged, they are formed so as to admit of a crib of wood, strongly hooped, or, what is preferable, of cast iron, to be fixed to the upper extremity of it. In order to keep the goods from the bottom of the boiler, where the heat acts most forcibly, a strong iron ring, covered with netting made of stout rope, is allowed to rest six or eight inches above the bottom of the boiler. Four double ropes are attached to the ring, for withdrawing the goods when sufficiently boiled, which have each an eye for admitting hooks from the running tackle of a crane. Where more boilers than one are employed, the crane is so placed, that, in the range of its sweep, it may withdraw the goods from any of them. For this purpose, the crane turns on spindles at top and bottom: and the goods are raised or lowered at pleasure, by double pulleys and shieves, by means of a cylinder moved by cast-iron wheels.

Before the year 1794, the apparatus used for making the oxymuriatic acid, was so very inconvenient and defective, that the health of the workmen employed was often injured, or at least their situation was rendered very uncomfortable, from the deleterious qualities of the gas. To remedy this defect, Mr. Peter Fisher, late of Rutherglen, near Glasgow, in the year 1794, invented an apparatus admirably calculated for this purpose, which, with very slight alterations, has been almost universally adopted. It consists of a leaden retort A, Fig. 4. Plate II. set on a tripod of iron D, into a cast-iron boiler B, built into brick-work, with a furnace and ash pit of the common construction EF. The top of the retort is closed with a leaden cover with screws and nuts, having an iron flenge of the same diameter above and below the mouth of the retort, with corresponding nuts and screws. The use of the flenge is to

Bleaching.

Plate 1.



H. Anderson fc.

prevent the retort fron being compressed out of shape, and thereby preventing its fitting properly. Between the joinings of the mouth of the retort, loose flax, dipt in white lead, ground in oil, is spread equally; and the whole is firmly screwed together. In the top of the cover, a circular hole is made of three inches in diameter, for introducing the materials for making the bleaching liquor, and cleaning out the retort. The hole is fitted with a plug of lead C, which is gently struck into the cover when the apparatus is arranged for working, and is luted with a little soft clay to prevent the escape of gas.

The oxymuriatic gas is conveyed by the lead tube G, which is two inches in diameter, into the intermediate vessel H, set upon a stand as in the figure. This vessel is circular, and is from 12 to 18 inches in diameter, according to the capacity of the other parts of the apparatus; the use of it is to prevent any impurity from descending by the leaden tube I into the receiver K, should the contents of the retort be forced upwards by the effervescence of the materials in it; but this is now seldom the case, since the distillation of the oxymuriatic acid is carried on by the use of the water bath, in place of heated sand.

The receiver K is a vessel of an inverted conical shape made of lead, where the capacity does not exceed 120 gallons, or of wood lined with lead when the quantity of work done is large. It is closely covered at top, and has a hole for introducing water into the receiver at M with a leaden plug. The brass stopcock for drawing off the oxymuriatic acid, is about two inches from the bottom of the receiver, as at N. In some apparatus of this kind, two or three false bottoms, as they are called, LL, made of lead, are laid on brackets of the same metal fixed to the side of the receiver. These false bottoms are pierced full of holes, in order to spread the oxymuriatic gas through the water during the distillation.

We shall now describe the preparation of the oxymuriatic acid combined with potash, as conducted in the apparatus invented by Mr. Fisher. See Plate II. Fig. 4.

Supposing the receiver K to contain 120 gallons English wine measure, it is filled at the hole M with a solution of caustic potash of the specific gravity of 1015; the lead stopper is then replaced. Twenty-one lbs. of common salt being intimately mixed with fourteen lbs. of the black oxide of manganese, the mixture is moistened with water, and wrought together until it is of the consistence of moist dough. By this means, the salt, in a state of solution, unites more intimately with the manganese. The top of the retort being removed, the salt and manganese are put into it; the cover is then replaced, and firmly screwed on its place.

Into 16lbs. of sulphuric acid pour gradually the same weight of water, and allow the mixture to cool. One half of the diluted acid is poured, by a lead funnel, into the retort by the hole at C, which is then closed by the lead plug to prevent the escape of the oxymuriatic gas which is instantly disengaged, after which a violent agitation is heard in the receiver K. The distillation is usually begun in the evening, and the workman, after seeing the operation going properly forward, leaves it to work of itself. In the morning, the distillation having abated, the remainder of the diluted sulphuric acid is poured into the retort, when a fresh disengagement of the gas takes place. As soon as it is observed to slacken, a fire is put into the furnace in order to heat the boiler B, which is filled with water, into which chaff or any similar light substance is put to prevent the evaporation of the water. By the increased heat of the water, the distillation goes forward with renewed vigour; and the fire is continued until no more gas is disengaged, which is known by the bubbling noise in the receiver being no longer heard. The oxymuriatic acid combined with potash may now be drawn off by the stop-cock N from the receiver for use.

In the above process, the sulphuric acid having a greater affinity for the soda contained in the common salt than that which the muriatic acid has, the latter is disengaged from the soda, and, acting on the manganese, it deprives it of its oxygen, which now existing in the state of oxymuriatic acid gas, by its expansive force is impelled forwards through the tubes G and I into the receiver K, where it is absorbed by the caustic alkaline solution.

Instead of caustic alkali, lime has been recommended, which from the experiments of Tennant, and subsequent practice, is found to answer the purpose of alkali, and is more economical. In the tub in which the lime is put, which is first slacked and made into a kind of paste with, or diffused in, water, some advise the addition of common salt; but this answers no good purpose, and seems rather to retard the formation of the bleaching liquor. When lime is used, in particular, it is necessary, in order to facilitate the combination of the acid with the lime, to use mechanical agitation. When a sufficient quantity, of pulverised lime, is

put into the receiver K in the place of potash, and mechanically agitated during the distillation of the oxymuriatic acid, it will be entirely dissolved, and forms a pure and transparent solution of oxymuriate, or rather hyperoxymuriate of lime. The apparatus lately put up at the cotton manufactory of Messrs. Craig and Marquedant, for bleaching cotton goods, which is after Tennant's plan, in which lime is used, answers the purpose extremely well.

On Bucking.—The process of bucking was long carried on without any improvement, until Mr. John Lourie, as before narrated, introduced an apparatus admirably calculated for conducting this operation on the large scale, which being in some measure self operative, much labour, as well as a considerable quantity of alkali is saved.

The boiler (Plate II. Fig. 2.) being filled with caustic alkaline ley, and the linens being properly arranged in the wooden kieve above it, the handle of the pump GG is set in motion by the machinery: the ley now flows through the pipe N by the working of the pump, and falling on the broad plate of metal MO, it is spread in a perpetual current on the cloth, while the valve K opening inwards, admits the ley to return into the boiler. Immediately on the pump being set to work, a fire is put to the boiler, by which the ley being gradually heated, the linens receive the benefit of the regular increase of temperature, and the colouring matter from the cloth is thereby more effectually removed. When the ley begins to boil, the handle of the pump is detached from the machinery of the water wheel, and by the ley being completely confined in the close boiler, it is forced up the pump, and falls in a perpetual stream through the pipe N upon the linens in the kieve ABCD.

The efficacy of this manner of conducting the bucking process must be evident at first sight: while the heat is gradually increased, a current of fresh ley is constantly presented to different surfaces of the goods for saturation, thereby rendering it more active in cleansing them. Besides, the manner in which the apparatus is first wrought by the water wheel, or steam engine, and its self-operating power afterwards, puts it completely out of the power of servants to slight the work, independent of the great saving of alkali, which, in most cases where it has been applied, amounts to from one-fourth to one-third of the quantity formerly used.

In making this preparation, the magnesian earth must be previously broken in water, as fine as possible, in the manner of starch. It is then introduced into the receiver K of the apparatus for making the oxymuriatic acid. (See Plate II., fig. 4.) Into the retort A one part of good manganese is introduced, on which is poured two parts of muratic acid, of the specific gravity of 1200 diluted with its bulk of water; the distillation instantly commences, and the magnesia is dissolved by the oxymuriatic acid. In order to keep the magnesia in suspension, it is necessary to agitate the liquor in the receiver occasionally by a staff similar to a churn staff, which is placed in the receiver, the handle coming up through the centre of the cover.

When the magnesia is dissolved, and the impurities which it may contain have subsided, it is drawn off for use. For this purpose, a clean copper is filled with pure water, and the heat is raised to about 160 or 170 degrees of Fahrenheit. So much of the oxymuriate of magnesia is then added as will give to the water in the copper a sensible taste of the salt. As soon as it is introduced, the whole must be quickly mixed together by a clean broom. The printed goods, having been previously slightly branned, are then quickly run over the wince into the copper; continuing to run them over the wince until the white is sufficiently clear. This operation takes only a few minutes. The goods are then carried to be streamed in pure water, to prevent the further action of the oxygen on the colours. By the addition of a little more of the oxymuriate of magnesia, fresh parcels of goods may be entered into the copper for clearing, and the process may be thereby continued for a whole day; after which the contents are run off from the boiler.

Besides the common processes for bleaching, another has been lately introduced with great success, by Mr. John Turnbull of Bonhill-place, in Dunbartonshire, for which a patent was granted him.

This method of bleaching consists of immersing the cotton or linen goods in a pretty strong solution of caustic alkali, and afterwards exposing them to the action of steam in a close vessel, (see Plate II. Fig. 3.)

A is the receiver, made of fir-deal boards firmly hooped, into which the cloth is laid loosely on the iron grating C. BB are iron hesps fixed to the side of the receiver, into which another hesp of iron, containing a screw D, is placed. This is moveable, and folds over by a joint, to make fast the cast-iron cover on the mouth of the tub or receiver: the joining of the

Bleaching.

PLATE II.

Fig. 1.

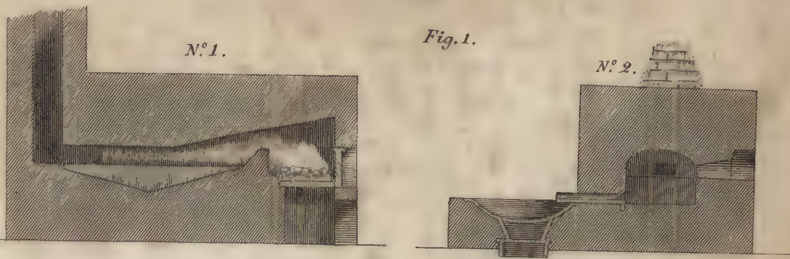


Fig. 2.

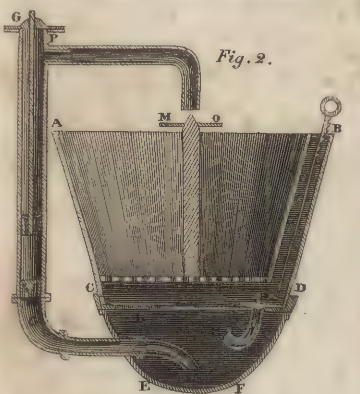


Fig. 3.

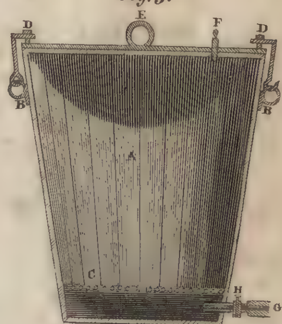
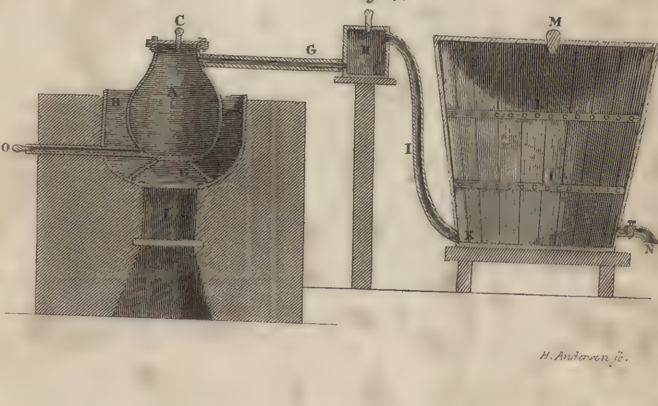


Fig. 4.



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lid is closely luted by plated rope being nailed to the mouth of the tub. The iron cover is put on its place, or removed at pleasure, by the hook of a crane being put into the ring E fixed in the centre of the lid. A hole is pierced through the cover, into which a wooden pin F is thrust, the use of which is to know when the steam is of sufficient strength.

The cotton or linen goods having been previously cleaned by steeping and washing, are, after being well drained, steeped in a solution of caustic alkali of the specific gravity of 1020. After the superfluous alkaline ley has been drained from them, they are arranged on the grating C in the receiver. The cover is then placed on the vessel, and firmly screwed down; and the steam is admitted by turning the stopcock H, of the pipe G, which communicates with a steam boiler of the common construction.

When the steam is admitted, the action of the alkali is increased by the heat, so as completely to dissolve the colouring matter of the cloth. The steaming is continued for some hours, after which the cloth is removed to the wash stocks, or dash wheel, in order to be cleansed; they are again immersed in the solution of alkali, and steamed in the receiver until they are suffciently white; after which they are soured and washed as in common bleaching. This process of whitening cotton or linen cloth, may also be forwarded by the assistance of the oxymuriatic acid at proper intervals.

At some extensive chemical manufactories, where it is necessary to evaporate very large quantities of liquid to a given strength, at a small expense, in place of evaporating these solutions in iron or leaden boilers, it is found more economical to construct what are called stone boilers for this purpose, Plate II. Fig. 1. No. 1, 2. These are nothing more than large oblong chambers, the side walls of which are about two feet high, built into the ground to prevent them from giving way. The outside of the wall is well rammed with tempered clay puddle, to prevent leakage. An arch of brick is then thrown over between the walls, which is covered with mortar to retain the heat. Proper openings are, at the same time, left to examine the state of the liquid: these are covered with a plate of iron. At one end of the chamber, a furnace of a sufficient capacity is built, having a breastwork interposed between it and the liquid, over which the flame plays. At the other end of the chamber, a vent of sufficient height is built to carry off the smoke. The fire being lighted, the flame plays along the surface of the liquid, which by this means is evaporated. Some of these stone boilers are so capacious as to contain 10,000 gallons.

English Iron Smelting Furnace.—We have noticed this furnace under the article IRON; but we have taken the drawing from one of Mushet. The following is a description: Figure 1st, of the plate, represents a blast furnace, with part of the blowing machine.

A, the regulating cylinder, eight feet diameter and eight feet high.—B, the floating piston, loaded with weights proportionate to the power of the machine.—C, the valve, by which the air is passed from the pumping cylinder into the regulator: its length 26 inches, and breadth 11 inches.—D, the aperture by which the blast is forced into the furnace. Diameter of this range of pipes 18 inches. The wider these pipes can with conveniency be used, the less is the friction, and the more powerful are the effects of the blast.—E, the blowing or pumping cylinder, six feet diameter, nine feet high: travel of the piston in this cylinder from five to seven feet per stroke.—F, the blowing piston, and a view of one of the valves, of which there are sometimes two, and sometimes four, distributed over the surface of the piston. The area of each is proportioned to the number of valves: commonly they are 12 to 16 inches.—G, a pile of solid stone building, on which the regulating cylinder rests, and to which the flanch and tilts of the blowing cylinders are attached.—H, the safety-valve, or cock: by the simple turning of which the blast may be admitted to, or shut off from the furnace, and passed off to a colateral tube on the opposite side.—I, the tuyere, by which the blast enters the furnace. The end of the tapered pipe, which approaches the tuyere, receives small pipes of various diameters, from two to three inches, called *nose pipes*. These are applied at pleasure, and as the strength and velocity of the blast may require.—K, the bottom of the hearth, two feet square.—L, the top of the hearth, two feet six inches square.—KL, the height of the hearth, six feet six inches.—L, is also the bottom of the boshes, which here terminate of the same size as the top of the hearth; only the former are round, and the latter square.—M, the top of the boshes, 12 feet diameter and eight feet of perpendicular height.—N, the top of the furnace, at which the materials are charged; commonly three feet diameter.—MN, the internal cavity of the furnace from the top of the boshes upwards, 30 feet high—NK, total height of the internal

parts of the furnace, 44½ feet.—OO, the lining. This is done in the nicest manner with fire bricks made on purpose, 13 inches long and three inches thick.—PP, a vacancy which is left all round the outside of the first lining, three inches broad, and which is beat full of coak-dust. This space is allowed for any expansion which might take place in consequence of the swelling of the materials by heat when descending to the bottom of the furnace.—QQ, the second lining, similar to the first. R, a cast iron lintel, on which the bottom of the arch is supported.—RS, the rise of the arch.—ST, height of the arch; on the outside 14 feet, and 18 feet wide.—VV, the extremes of the hearth, ten feet square. This and the bosh stones are always made from a coarse gritted freestone whose fracture presents large rounded grains of quartz, connected by means of a cement less pure.

Figure 2. represents the foundation of the furnace, and a full view of the manner in which the false bottom is constructed.

AA, the bottom stones of the hearth. B, stratum of bedding sand. CC, passages by which the vapour, which may be generated from the damps, are passed off. DD, pillars of brick. The letters in the horizontal view, of the same figure, correspond to similar letters in the dotted elevation.

Figure 3, AA, horizontal section of the diameter of the boshes, the lining and vacancy for stuffing at M. C, view of the top of the hearth at L.

Figure 4, vertical side-section of the hearth and boshes; shewing the tymp and dam-stones, and the tymp dam-plates. *a*, the tymp-stone. *b*, the tymp-plate, which is wedged firmly to the stone, to keep it firm in case of splitting by the great heat. —*c*, dam-stone, which occupies the whole breadth of the bottom of the hearth, excepting about six inches, which, when the furnace is at work is filled every cast, with strong sand. This stone is surmounted by an iron plate of considerable thickness, and of a peculiar shape, *d*, and from this called the dam-plate. The top of the dam-stone and plate is two, three, or four inches under the level of the tuyere hole. The space betwixt the bottom of the tymp and the dotted line is also rammed full of strong sand, and sometimes fire-clay. This is called the tymp-stopping, and prevents any part of the blast from being unnecessarily expended.

The square of the base of this blast-furnace is 38 feet; the extreme height from the false bottom to the top of the crater is 55 feet.

A Furnace for Cast Iron Founders.—Mushet gives the following description. See plate.

Fig. 1, a ground plan of two large air-furnaces, and chimney for melting pig or cast-iron with the flame of pit coal.

The letters A B C D point out the exterior dimensions of the stalk or chimney, which is first erected, leaving two openings or arches, into which the fore-part of the furnaces are afterwards built. The breadth of the chimney at the particular place which the plan exhibits, is 16 feet from A to B, and from A to D or from B to C 6 feet 6 inches. The plan is drawn at that elevation where the flame enters the chimney by the flue or throat, narrowed on purpose to throw back part of the flame, and keep the furnace equally hot throughout, as may be more particularly viewed in the vertical section, fig. 2.

EE, the furnace bars on which the coals rest, and where the combustion is maintained.

FF, openings called teasing-holes, by which the coals are introduced to repair the fire.

GG, fire-brick buildings called bridges. These are meant to concentrate the flame, that it may act as violently on the metal as possible. Upon the height of the bridge, much depends in fusing the metal speedily, and with little loss. The height of this may be seen in the vertical section, fig. 2. G.

HH, the charging doors, by which the metal is introduced in the shape and state of pig-iron, lumps, scraps, &c. &c. The iron generally occupies the furnace across to I, called the back wall, and is never meant to approach the bridge nearer than the dotted line, lest the metal in melting should run back into the grates, in place of descending into the general reservoir or cavity below. The corners or notches, *h*, *h*, *h*, *h*, receive a stout cast-iron frame lined with fire-bricks. This is hung by means of a chain and pulley, and can be raised and depressed at pleasure. This frame is, properly speaking, the charging-door, and is always carefully made air-tight by means of moistened sand.

KK, the flues or openings by which the flame enters the chimney. These are 15 inches by 10. On maintaining these openings of a proportionate size to the other parts depend in a great measure the powers and œconomy of the furnace.

LL, lading doors, by which ladles are introduced, in the case of small furnaces, to lift out the metal and distribute it to the various moulds.

M M M M, binding bolts to limit with-

English Smelting Furnace.

Fig. 3.

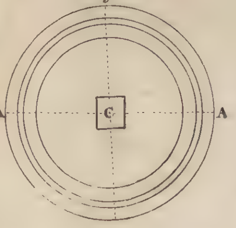
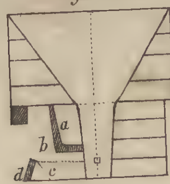
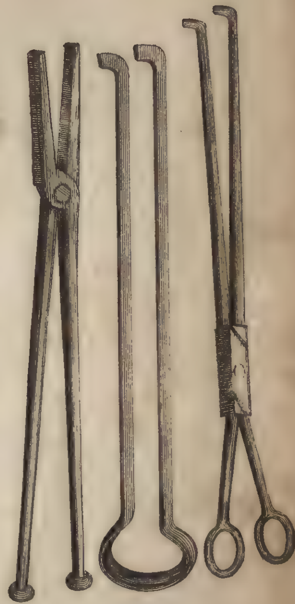


Fig. 4.





Chemical Tongs.

Fig. 1.

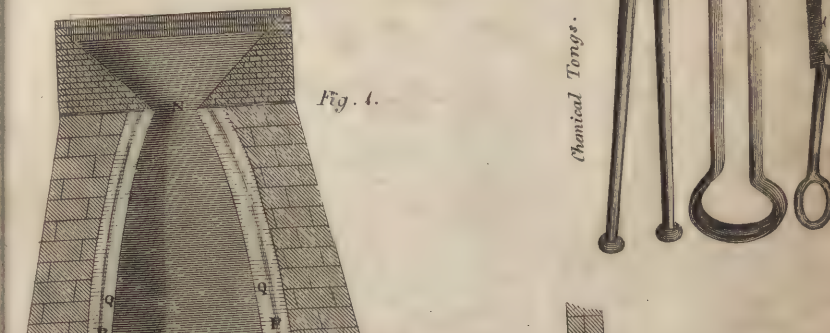
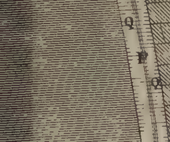


Fig. 2



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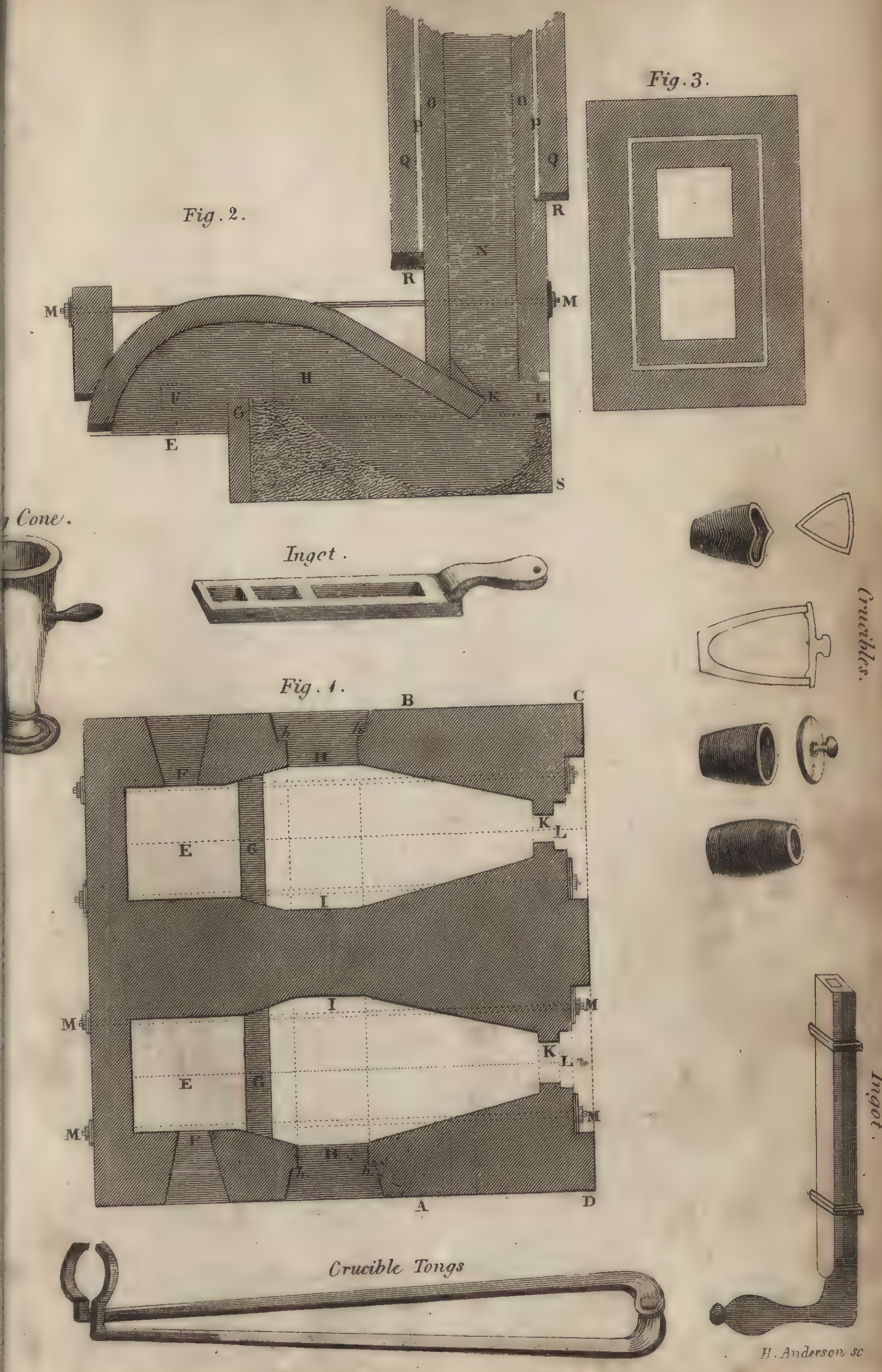
Air Furnace for Cast Iron Foundries.



Steel Furnace.

Fig. 2.

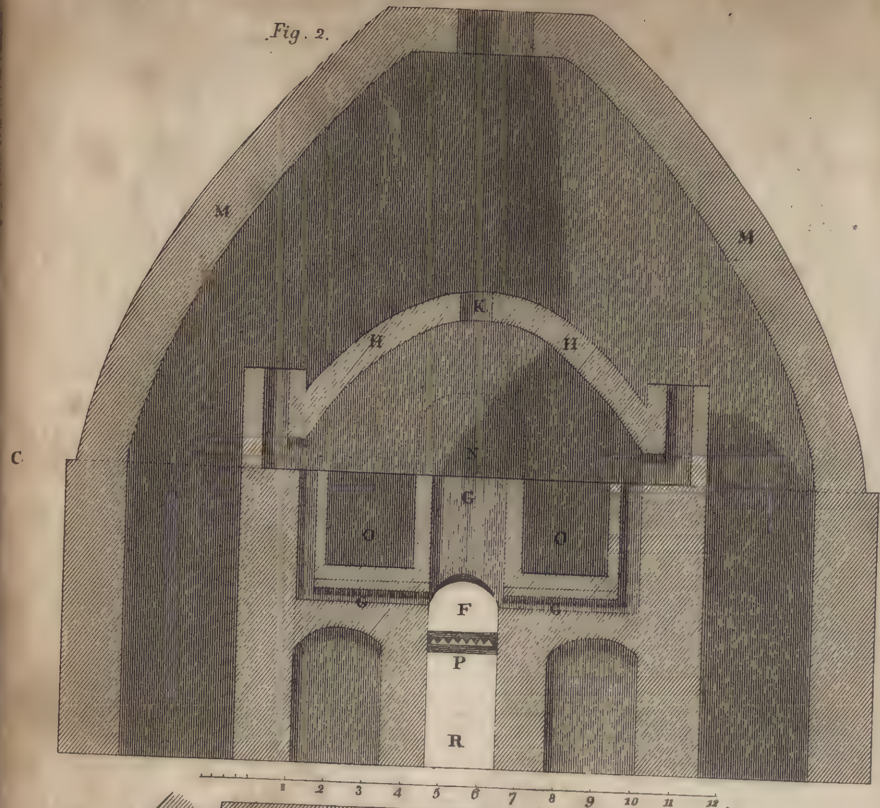
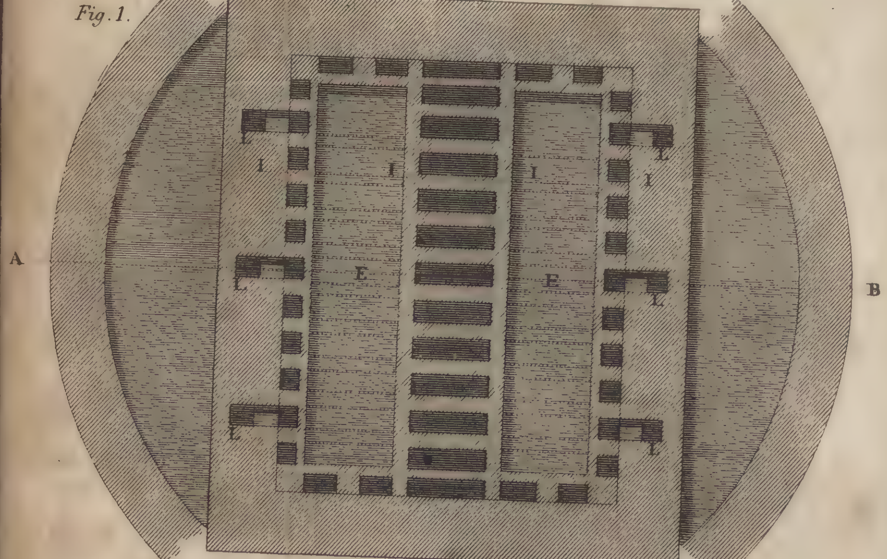


Fig. 1.



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in proper bounds the expansion which takes place in the building when the furnace is highly heated.

Fig. 2. vertical section of one of the furnaces, and its appropriate stalk or chimney.

E, the grates.

F, the teasing-hole.

G, the bridge.

H, the charging door.

K, the flue or opening into the chimney.

L, the lading door.

M M, the binder or binding bolt.

N, the interior of the stalk or chimney, 30 inches square.

O O, the fire brick-work, 9 inches thick.

P P, space of 2 inches for stuffing with sand.

Q Q, common brick building.

R R, cast-iron lintels, over which are thrown double 9-inch arches, so that at any time the inferior building can be taken down to make repairs, without shaking or in the least injuring the chimney.

S. The dotted lines here are meant to represent what is called the tapping-hole. When a large piece of goods is to be cast, lifting the metal with ladles would be impracticable. A sharp-pointed bar is driven up this opening. The iron then flows freely out into a large bason of sand made for its reception. It is then conducted, by collateral channels, into the mould.

The space under the curved dotted line from G to L, by S, is filled with a mixture of sand and ashes. When the furnace is prepared to melt, the whole of the bottom receives a stratum of sharp clean sand about two inches thick. This is broken up at night, and fresh sand is substituted for it before the fire is kindled in the morning.

Fig. 3. is a horizontal section of the chimney or stalk, taken where the flues assume a perpendicular direction. The letters in this figure correspond to those in the vertical section, fig. 2. The height of the chimney ought not to be less than 45 feet: if 50 feet, the effect will be sooner and of course better produced.

Steel Furnace.—Colier, in the Transactions of the Manchester Society, gives the accompanying plate of a furnace, for the manufacture of steel.

Explanation of the Plate.—Fig. 1. is a plan of the furnace, and fig. 2. is a section of it taken at the line AB. The plan is taken at the line CD. The same parts of the furnace are marked with the same letters in the plan and in the section. EE are the pots or troughs into which the bars of iron are laid to be converted. F is the fire-place; P the fire-bars; and R the ash-pit. GG, &c. are the flues. HH is an arch, the inside of the bottom of which corresponds with the line IIII, fig. 1. and the top of it is made in the form of a dome, having a hole in the centre at K, fig. 2. LL, &c. are six chimneys. MM. is a dome similar to that of a glass-house, covering the whole. At N there is an arched opening, at which the materials are taken in and out of the furnace, and which is closely built up when the furnace is charged. At OO there are holes in each pot, through which the ends of three or four of the bars are made to project quite out of the furnace. These are for the purpose of being drawn out occasionally to see if the iron be sufficiently converted.

The pots are made of fire-tiles or firestone. The bottoms of them are made of two courses, each course being about the thickness of the single course which forms the outsides of the pots. The insides of the pots are of one course, about double the thickness of the outside. The partitions of the flues are made of fire-brick, which are of different thicknesses, as represented in the plan, and by dotted lines in the bottom of the pots. These are for supporting the sides and bottoms of the pots, and for directing the flame equally round them. The great object is to communicate to the whole an equal degree of heat in every part. The fuel is put in at each end of the fire-place, and the fire is made the whole length of the pots, and kept up as equally as possible."

Description of Plate No. 1—Farriery.

A. The head, including all its parts as articulated with the neck.

BB. The blade bone, or scapula.

G. The humerus, or shoulder-bone.

DD. The bones of the leg, or fore-arm, consisting in each of the radius and ulna.

EE. The joints of the knees, with the small ranges of bones.

FF. The posterior parts of the knee joints.

GG. The shank-bones, consisting in each of the canon bone, and the two metacarpal, or splent-bones.

HH. The great pastern bones, with the two sesamoid bones of each fetlock.

II. The lesser pastern bones.

KK. The bones of the feet, consisting in each of the coffin and navicular bones, with the lateral cartilages.

LL. The bones of the pelvis, called ossa innominata.

MM. The thigh-bones.

NN. The bones of the hind-legs; consisting in each of the tibia and the fibula.

OO. The points of the hocks.

PP. The small bones of the hocks.

QQ. The bones of the insteps; consisting, in each, of the canon bone and two metatarsal bones.

RR. The great pasterns and sesamoid bones of the hind-legs.

SS. The little pastern bones of the hind-legs.

TT. The coffin and navicular bones of each hind-foot, with the lateral cartilages.

V. The sternum, or breast-bone.

X. The point of the sternum.

YY. The ribs.

Z. The cartilaginous ends of the ribs on the breast and abdomen.

I. II. III. IV. V. VI VII. The seven vertebræ of the neck.

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18. The eighteen vertebræ of the thorax and back.

1, 2, 3, 4, 5, 6. The six vertebræ of the loins.

1, 2, 3, 4, 5. The five spines of the os sacrum

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18. The eighteen joints of the coxendix and tail.

Description of Plate No. II.—Farriery.

Representing the intestines of the horse as they appear in their natural situation, when the abdomen is laid open.

AAAAAA. The colon, with its various circumvolutions and windings, together with its numerous folds, and under which lie the small intestine.

B. The cœcum, or blind gut.

C. The rectum.

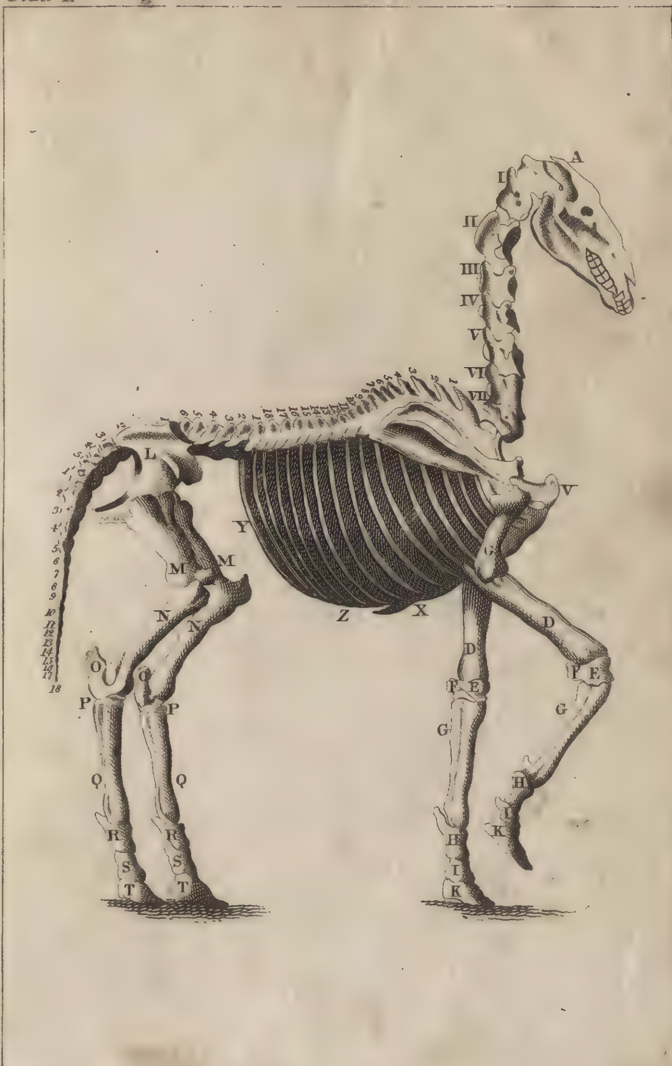

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Plate II. FARRIERY.

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